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Estimation of Transportation Charge Relationships for Frozen Vegetables

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GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS

Giannini Foundation Research Report No. 287
May 1966

FOREWORD

This report is another in a series concerned with the competitive position of the western region of the United States in the marketing of frozen fruits and vegetables.

The present study began as part of a more comprehensive study by Melvin Wagner dealing with the competitive position of several frozen vegetables. In such an analysis of interregional competition, knowledge of demand characteristics, supply characteristics, and transportation charges is essential. The estimation of transportation charges for use in such studies is the objective of this report. Although the initial objective was to obtain such charges for frozen vegetables, there is much emphasis on the estimation, use, and logical basis for transfer charge relationships derived from a sample of quoted charges with an attempt to probe a little deeper than has been done heretofore in studies of interregional competition.

The work was done as a contribution to Western Regional Research Project No. WM-17, Economic Factors in Plant Location and Organization for Freezing Western Fruits and Vegetables, and the continuing Project No. WM-47, Economic Factors Affecting the Location, Production, and Marketing of California Processed Fruits and Vegetables, both cooperative projects with the U. S. Department of Agriculture and other states in the western region.

ACKNOWLEDGMENTS

Many people contributed to this study in one way or another. For their efforts in supplying data and information, the following persons deserve special mention: Donald C. Fowle of Stokely-Van Camp, Inc.; Bill Moore of Southern Pacific Company; Fred Lucian of Pacific Intermountain Express Company; and L. F. Hynek of Consolidated Freightways. Credit is also extended to Melvin Wagner for his helpful assistance and cooperation in the early stages of the study. For his encouragement in developing the ideas and his helpful comments after reading early drafts, the author extends his sincere appreciation to Lee Bawden. For the large amount of computation, credit must go to Emily Lachmann of the Statistical Pool of Giannini Foundation. Finally, much credit is due Ben C. French for the many helpful comments and suggestions resulting from thorough reviews of two drafts of the manuscript and for his attempts to make the report understandable to other readers. If he did not fully succeed, the burden rests with the author, as it does for any errors that remain.

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ESTIMATION OF TRANSPORTATION CHARGE RELATIONSHIPS FOR FROZEN VEGETABLES

by

Richard C. Haidacher[1]

Introduction

Production areas for frozen vegetables are not usually coincident with consumption centers for such commodities and are often far removed. For example, approximately two-thirds of the pack of frozen fruits and vegetables, excluding citrus, originates in the western states of California, Oregon, Washington, and Idaho; and over 60 percent of this pack is estimated to move to points east of the Mississippi River.[2]

Costs of providing the rather specialized transportation service play an important role in allocating market shares to the various producing regions and in determining the locations of these regions. Changes in these costs may also influence the number and size of processing firms and the prices that consumers must pay for the final product.

This study was undertaken primarily to provide estimates of transfer charges to be used in an analysis of interregional trade flows and possible future production locations. Such a study requires a very large number of point-to-point transfer charges for both rail and motor carrier shipments. Obtaining this number of individual charges from carriers and other agencies is a lengthy and costly task. An alternative procedure followed here is to estimate general relationships between transfer charges, distance, and other factors involved from samples of freight rate data. These functions may then be used to approximate transfer charges between any two points.[1]

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[2] Robert B. Reese and Earl B. Miller, Geographic Distribution of Western Frozen Fruits and Vegetables, U. S. Agricultural Marketing Service, Marketing Research Report No. 441, 1960, 40p.

Transportation functions such as these are not suitable as short-run decision aids for individual firms. That is, a processing firm could not satisfactorily use such a relationship to estimate charges for a load of frozen vegetables it expected to ship between two points. However, such relationships may be of value in long-term planning. For example, a processor could utilize the cost-distance relationships in decisions concerning future plant location and plant size and in determining the possible effects of changes in the overall level of charges on processing cost and volume. Individual transportation firms might also use these relations for the purpose of comparing their own rates with the overall transfer charge structure.

There has been little if any attempt to evaluate the procedure mentioned above, either in terms of its accuracy or the logic upon which it is based. While this report is not intended to fulfill this requirement, another objective of it is to make available to other researchers an evaluation of some analytical techniques used in obtaining the estimates of transfer charge relationships.

The report is organized in five major sections. The first section discusses some of the institutional and economic characteristics concerning rates, rate establishment, and costs. The second deals with the methodology and data. The third section presents empirical estimates of transfer charge-distance-weight relationships for both rail and motor carriers. The fifth section compares the result of this study with those of other studies and attempts to evaluate the results in terms of their limitations and usefulness. The final section is a brief summary.

The Structure of Transportation Costs and Charges

As pointed out by Weber, the term "transportation costs" in general usage has two interpretations:[2]

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[1] This approach was used in a study by Carleton Cecil Dennis, "Interregional Competition in the Frozen Strawberry Industry" (unpublished Ph.D. dissertation, Department of Agricultural Economics, University of California, Berkeley, 1959), 236p. Preliminary explorations suggested that estimation of alternative charge relationships was warranted. The results of the two studies are compared. Infra, pp. 65-71.

[2] Alfred Weber, Theory of the Location of Industries, trans. Carl J. Friedrich (Chicago: University of Chicago Press, 1959), p. 41.

> ". . . transportation costs in the sense of political economy, and transportation costs as understood by the business man paying for the shipment of goods. The former costs are the total amount of goods and labor that are absorbed in effecting such a shipment. The latter costs are the monetary payment made to those furnishing the transportation."

In order to avoid confusion, throughout the remainder of this report we shall call the former "transportation costs" and the latter "transfer charges." The same distinction shall apply when the terms "costs" and "charges" are used with or without qualifying words such as "transportation" and "transfer."

From an economist's point of view, rates and charges are expected to be related, more or less, to the cost of providing the service. However, it is well known, particularly in the transportation industry, that institutional as well as economic factors are important determinants of the existing structure of rates and charges. As in most economic investigations, there are many factors, generally known by persons in the industry concerned, with which a research worker must become familiar. The main sources of such information for the investigator are the general literature on the subject, previous studies, and correspondence or interviews with persons associated with the industries concerned. The following paragraphs summarize information obtained from these sources concerning certain institutional and economic characteristics which are relevant background material. Attention is focused on the general structure of rates in practice, the procedures and rationale used in rate establishment, and the nature and relevance of costs of the services provided in establishing charges, although specific interest is in the relationship of these factors to transfer charges for frozen fruits and vegetables.

Regulatory agencies, such as the Interstate Commerce Commission, are an important institutional factor in the determination of rates and charges for both rail and motor carriers of frozen vegetables. Bunting discusses the reasoning, historically, of the Interstate Commerce Commission in establishing railroad rates and the relation of rates to distance, indicating that a progressive relationship between rates and distance may exist but that it is obscured because of the consideration of other factors in rate establishment.[1/] In its decisions, the regulatory commission considers such factors as historical and legal precedent, the nature and value of the commodity transported, the

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[1/] James Whitney Bunting, The Distance Principle in Railroad Rate Making (University Park: University of Pennsylvania, 1947), 95p.

nature and degree of competition with other transport agencies, geographic location, and traffic density. Congressional committees have conducted several investigations of interterritorial freight rates which show a progressive relationship between first-class rates and distance with rates increasing with distance but at a decreasing rate.[1] One of the studies presents a relationship between railroad transportation costs and the factors of weight and distance. According to this relationship, total unit costs are a linear function of weight for a given distance and a linear function of distance for a given weight. When both distance and weight increase, total unit costs increase at an increasing rate.[2] Daggett and Carter give an excellent descriptive analysis of transcontinental rail freight rate structure and some of the factors determining that structure such as terrain; competing transport agencies; and rate groups, zones, territorial classifications, etc.[3] They present rate profiles (rates plotted against distance from a given shipping point to points en route to a particular destination) for several agricultural commodities indicating a very irregular step relationship of rate to distance, which usually approaches the horizontal at distances of about 3,000 miles.

The foregoing, together with the content of various other sources, indicates that general rail rates (for example, first-class freight rates) are related to distance such that rates tend to increase with distance at a decreasing rate. This relationship is modified or distorted, more or less, by geographical,

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1/ U. S. Congress, House, Regionalized Freight Rates: Barrier to National Productiveness, 78th Cong., 1st Sess., 1943, House Doc. 137, 79p.

Idem, The Interterritorial Freight Rate Problem of the United States, 75th Cong., 1st Sess., 1937, House Doc. 264, 66p.

Idem, Supplemental Phases of the Interritorial Freight Rate Problem of the United States, 76th Cong., 1st Sess., 1939, House Doc. 271, 61p.

Idem, Report on Interterritorial Freight Rates, Letter from the Board of Investigation and Research, 78th Cong., 1st Sess., 1943, House Doc. 303, 384p.

2/ Idem, Regionalized Freight Rates: . . ., pp. 61-66.

3/ Stuart Daggett and John P. Carter, The Structure of Transcontinental Railroad Rates (Berkeley and Los Angeles: University of California Press, 1947), 165p.

institutional, legal, and competitive factors, resulting many times in a very obscure relationship between rates and distance. Substantial rail traffic moves under commodity and exception ratings, which are only two of the many special rate classifications.[1] And these two rates are said to bear an even more obscure relationship to distance and other cost factors than do first-class rates.[2] The progressive relationship indicated between first-class rates and distance is an imperfect and indirect reflection of the relation between cost and distance, which might be expected to be linear, as indicated above.[3]

The reflection is imperfect because distance is not the only important factor affecting cost and because costs are not the only factor (and may not always be the decisive one) considered in the establishment of certain rates, as indicated in much of the literature on the subject.[4] In general, there appear to be three principles involved in the establishment of a particular rail rate. The lower limit for the rate is determined by the direct or variable costs associated with the service involved. The upper limit is determined by the value of the commodity or, more specifically, by the difference in the value of the place utility between origin and destination. The principle is usually called "value of service pricing." Between these limits, the rate is determined by the degree of competition and the principle of "what the traffic will bear."

Motor carriers of frozen vegetables were returned to a regulated status under the Interstate Commerce Commission in 1958. Although regulation is not as extensive and detailed as for rail carriers, these motor carriers must comply with the regulations of the Commission on posting, changing, and filing of rates, among other things.[1] Such regulation has been shown to affect both charges and services provided by these carriers.[2] Concerning the establishment of motor carrier rates, available information is relatively scarce, but there is some indication that regulated motor carriers tend to "ape" the railroad rate structure.[3] While Daggett and Locklin discuss the economic factors that possibly affect motor carrier costs, little was found that indicated the nature and form of the relationship between costs and the factors of weight, distance, etc.[4]

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[1] U. S. Interstate Commerce Commission, Carload Waybill Statistics, 1959: State-to-State Distribution, Products of Agriculture, Traffic and Revenue, Statement SS-2, October, 1960, 92p.

U. S. Congress, House, Report on Interterritorial Freight Rates. . . .

[2] *Ibid*., pp. 341-342.

[3] U. S. Congress, House, Regionalized Freight Rates: . . ., pp. 61-66.

[4] For example:

Bunting, *op. cit*.

Philip D. Locklin, Economics of Transportation (5th ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1960), 874p.

The Methods and Data

There are several alternative approaches that might be employed to obtain transfer charges for use in interregional studies. For expository convenience, we might label these alternative methods as (1) the cost-determination approach, (2) the survey approach, and (3) the statistical approach. The latter is a somewhat ambiguous label in that the first approach could also be statistical in nature. Actually, these designations are used only to characterize the general approach, and each category may contain various alternative empirical procedures. The following is a very brief description of the essential characteristics of each of these general methods indicating the assumptions for each, their limitations for use in interregional studies, and the relative cost of each in terms of time and other resources required.

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[1] U. S. Interstate Commerce Commission, Motor Transportation of Commodities Formerly Exempt from Economic Regulation, Information Bulletin No. 1, August, 1958, 8p.

[2] U. S. Agricultural Marketing Service, Interstate Trucking of Frozen Fruits and Vegetables Under Agricultural Exemption, Marketing Research Report No. 316, 1959, 88p.

[3] George W. Wilson, "Effects of Value-of-Service Pricing Upon Motor Common Carriers," Journal of Political Economy, Vol. 63, No. 4 (August, 1955), pp. 337-344.

[4] Stuart Daggett, Principles of Inland Transportation (New York: Harper and Brothers, 1955), 788p.

Locklin, *op. cit*.

Theoretically, the cost-determination approach assumes a perfectly competitive, static model of the transportation industry where transfer charges in the short run are equal to marginal cost above average variable cost and in the long run are equal to minimum long-run average total unit cost. Institutional factors are held to be of no consequence. Under these extreme conditions, one need know only the complete set of cost-output relations; and from this, transfer charges can be obtained, given the demand, because there is a one-to-one correspondence between long-run average costs and charges. For distances having no established transfer charges, the charges can be estimated also from the cost relations if the values of the cost determinants such as weight, distance, etc., are known. The derived cost relations can be compared for each mode of transportation to select the least-cost alternative. Obtaining the cost relations in this approach may be extremely involved and quite expensive in terms of time and other resources relative to the other methods.

The survey approach is probably at the opposite extreme from the cost-determination method. It either makes no assumption at all about the relationship of costs to charges, or it assumes there is no systematic relationship between the two. While this method might be expected to furnish the most accurate estimates by minimizing discrepancies due to zone rates and rate classifications, it does not provide information on transfer charges for point-to-point distances that may be of economic interest but for which rates have not been established or are not readily available. To the extent this data requirement is not fulfilled, a limitation is imposed on the interregional analysis as a predictive device in the static sense. Where alternative modes of transportation exist, each point-to-point charge must be compared to select the most economic alternative. Relative to the other methods, this approach may be very time-consuming for interregional studies of commodities that have national distribution and alternative means of transport but inexpensive in terms of other resources.

The statistical approach is essentially a combination of the above methods. In essence, it attempts to derive functional relations between transfer charges and cost determinants from a sample of transfer charges. These functional relations are then used to estimate transfer charges for distances which have no published rates and those not contained in the sample. They are also used to select the most economic alternative between the various means of transport. Theoretically, this method assumes an imperfectly competitive, static model of the transportation industry where rates are related to cost determinants in some systematic fashion but are not necessarily equal to costs. That is, the level of charges cannot be determined from cost alone. The discrepancy between charges and cost of the service is taken to be a result of institutional considerations, the degree of competition from competing transport agencies for particular hauls, and other miscellaneous factors. These factors are not expected to be systematic but more or less random in their effect on charges. As these random effects increase in importance in the establishment of particular charges, the predictive ability of the functional relation decreases. In terms of time and other resources, it may be more or less expensive than the survey method, depending on the difficulty of obtaining the sample of rates; but it should be considerably less expensive than the cost-determination approach in both respects. Also, it should be pointed out that there is no guarantee that plausible results will be obtained with either the cost-determination approach or the statistical approach.

The particular approach adopted depends on the assumptions made concerning the relative importance of the various economic and institutional factors in determining the structure of transfer charges and, given this, an assumption concerning the relationship between cost determinants and the structure of transfer charges. Additionally, it depends on the time and resources available to the investigator and the usefulness of the results for interregional studies.

The disadvantages of the survey approach are believed to outweigh its advantages of additional accuracy and less restrictive assumptions. Provided that the more restrictive assumptions are valid, the other two methods are more useful and more convenient for interregional studies. That is, provided that competition is an important influence generally, entry is not completely blocked, and regulatory agencies consider cost an important element when ruling on rates, there is reason to believe that transfer charges are in some systematic way related to the cost of the service involved, and, hence, there is justification for basing the empirical estimation procedures in part on a theory of transportation costs. It is usually recognized that some degree of competition does exist between transportation agencies such as motor carriers and railroads[1/] and that there is increasing emphasis being placed on cost considerations in

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[1/] Ibid.

the establishment and justification of rates and charges.[1] However, as mentioned previously, the criteria for establishing charges in practice indicate a divergence from anything approaching perfect competition.[2] In view of this, the assumptions of the statistical approach appear more valid than those of the cost-determination approach when the results are to be used in the estimation of transfer charges for interregional studies.

Data and Data Sources

Of all the factors that either constitute or influence transfer charges, transportation agencies indicated that data on basic freight rates, corresponding minimum load weights, and refrigeration charges could be obtained from firms engaged in the transportation of frozen vegetables and possibly from large frozen vegetable processors who maintained special traffic departments. A mimeographed form consisting of 684 point-to-point distances was supplied to several firms along with a request for the above information.[3]

For motor carrier transport, both carriers and processors were contacted. Because of regulations which limit the routes over which a particular motor carrier is authorized to operate, carriers had to be contacted in each of the various regions for which charges were desired. Approximately 500 of the required charges (the basic rate plus refrigeration charges) and the corresponding minimum load weights were obtained. Commodity rates (as opposed to class rates and special rates) were specified in the instructions, and, with only a few exceptions that were discarded in compiling the data, commodity rates were obtained to the best of our knowledge. Many of the point-to-point charges were duplicated; and for certain distances several charges, some higher than others, were obtained. For those points between which charges were not obtained, either commodity rates did not exist, a reply was not received, or the right carrier was not contacted. The reason was not always known.

For rail transport, data were obtained from railroad agencies and processors. Initially, one railroad was contacted, and it contacted other railroads throughout the United States to obtain rates it did not have available. Because the basic freight rates and refrigeration charges are quoted separately in rail tariffs, the request specified that the basic rate plus all other charges were desired for each point-to-point distance. Somehow this specification was misplaced, and the cooperating railroads furnished only basic freight rate data, much of which was obtained too late to be used in the present analysis. However, one of the processors furnished total charges for about half of the required distances. Consequently, the data were divided into two sets and analyzed separately. Both of these sets consisted of a mixture of commodity and class rates, whichever existed for the particular points. For all rates and/or charges, corresponding minimum load weights were furnished.

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[1] U. S. Agricultural Marketing Service, The Marketing and Transportation Situation, MTS-143, October, 1961, pp. 18-21; and MTS-145, May, 1962, pp. 16-18.

[2] Supra, p. 5, paragraph 2.

[3] These point-to-point distances were derived from a matrix of production and consumption centers for frozen vegetables; see Appendix.

For both rail and motor carriers, charges are quoted in cents per hundredweight, and minimum load weight is quoted in thousand pounds.

Data on Distance.--Ideally, actual distance between any two points by rail or highway, depending on the type of transport, might be desired. However, these distance measurements are not always readily available, may be difficult to measure, and do not facilitate comparison of transfer charge functions for selecting the least-cost means of transport. Considering the use of the transfer charge functions in this type of study, it seems desirable to use the same distance measure throughout. Published railroad distances between points in the present study were not found. The foregoing, along with comments of other workers concerning the comparability of measurements, indicates that airline distance would be the preferable measure unless functions fit the data considerably better using highway mileage.1/ Therefore, both highway and airline distance measurements were obtained.

Highway distances were obtained directly from Mileage Guide No. 4 where the necessary points were listed.2/ If the particular origin or destination was not given, the point nearest to it was used, and the published mileage was

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1/ U. S. Bureau of the Census, Transportation and Distribution of Canned Foods, October, 1959, p. 4.

Idem, Transportation of Fresh Fruits and Vegetables by Agricultural Assemblers, September, 1958, pp. 2, 8, 12, and 20.

2/ Household Goods Carriers' Bureau, Mileage Guide No. 4 (Washington, D. C., December, 1941), 384p.

adjusted by the appropriate highway distance obtained from a recent highway map. For many of the points, published airline distances were obtained directly from Airline Distances Between Cities in the United States.[1] If the points were not given, the published distance for points near the desired points were adjusted by using the measured difference in straight-line distance from a map.[2] The data on quoted rail and motor carrier charges and the distance measurements are presented in Appendix Tables 1 through 5.

A Priori Relationships Between Transportation Costs and the Variables, Weight and Distance[3]

In addition to the relationship of costs to charges postulated for the statistical approach, this approach requires some theory about the expected relationship between costs and the economic factors which affect costs or cost determinants. However, there is little in the way of a formal cost theory in the economics of transportation which is comparable to traditional price theory. The absence of such a formal development, although it would be helpful if it did exist, is not a serious obstacle in terms of the objectives of this study because our interest is not in a detailed cost analysis per se as in the cost-determination approach. The primary use of such a theory of transportation costs is to specify, a priori, the important economic variables that may be functionally related to a sample of quoted transfer charges and to delimit the range of alternative functional forms that should be considered on the basis of the costs of transportation. Subsequently, the form of the relation may be altered by utilizing available knowledge about the institutional and competitive structure of the industry.

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[1] U. S. Department of Commerce, Coast and Geodetic Survey, Airline Distances Between Cities in the United States, Special Publication No. 238, 1947, 246p.

[2] With accurate measurement and an accurate map, it was found that errors were much less than 1 percent when compared with published distances, even for distances from coast to coast. However, it was later learned that computer programs are available which compute the airline distance, given the geographic coordinates of the origin and destination points.

[3] A journal article of direct relevance to this section was discovered during the review of the second draft of this manuscript, and, consequently, this report did not benefit from pertinent information that may be contained in that article and in references cited therein. See Vernon L. Smith, "Engineering Data and Statistical Techniques in the Analysis of Production and Technological Change: Fuel Requirements of the Trucking Industry," Econometrica, Vol. 25, No. 2 (April, 1957), pp. 281-301.

Although in several essential aspects the transportation industry is unique, as compared to the classical examples of firms and industries of traditional production theory, this theory can be usefully employed in developing the necessary a priori cost relationships. And, while we must consider both rail and truck transportation costs, the differences between the two are expected to be primarily quantitative in nature with respect to the variables considered here.[1/] Qualitative differences may exist, however, because of legal and institutional factors.

From an economic point of view, the important cost relationships are those which relate costs to output in a functional manner as opposed to cost equations representing accounting identities. Further, our interest centers primarily on the short-run cost functions.[2/] These cost-output relations are derived from the basic technical relation in which output is functionally related to various inputs. This is a physical relationship, the exact form and nature of which is only determined by the given techniques of production. Even though the exact relationship is not available, one may still be able to say something about the general form of the relation of cost to output by utilizing certain economic concepts, such as the law of diminishing returns, provided certain conditions are known to prevail. In order to proceed further with our discussion of cost functions, we must first describe in general terms what the inputs and outputs are for a transportation firm.

Broadly speaking, the inputs of a transportation firm are not much different from those in the usual examples of a firm. There is a category of inputs that are fixed for the short run and do not vary with output. These include the terminal facilities, the equipment or vehicles used for transport, and possibly land in terms of rights-of-way. Then there is the class of inputs,

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[1/] Daggett and Locklin indicate that fixed costs are higher for rail than for truck; see Daggett, *op. cit.*, and Locklin, *op. cit.*

[2/] That is, the static short run from the standpoint of the transportation firm and not necessarily short run from the viewpoint of the user of transportation services. The static short run is selected because our interest is in the *form* of the cost relations with respect to variations in distance and weight. While the static short-run, fixed cost items will affect the *level* of the cost relationships, they will not alter greatly, if at all, the *form* of the functions with respect to the variables, distance and weight.

called "variable factors," which vary with output, such as fuel, labor, and lubrication. Other items, usually included in the term "user costs," such as the durable factors consumed in the production of a given output, may also be included. There are certain topographical factors that would in reality affect costs through their effect on the use of inputs, such as the type of road, road surface, curvature, and grades. But these factors will vary for each point-to-point distance and are not amenable to generalization, so we abstract from them in our discussion.[1]

The output of a firm in a service industry, such as a transportation firm, is somewhat more difficult to specify in measurable terms than it is for a firm producing a physical product such as corn or steel. This is partially a result of the fact that the product or service has more than one dimension. The basic dimensions of output for a transportation firm are weight and distance, which is to say that the primary service is the movement of weight a given distance.[2] But the time required to perform the primary service is also part of the product along with all of the tasks incident to the basic service, such as loading, unloading and delivery, stops en route, waiting time, etc.

Any general approach to such a development of the theoretical relationships would undoubtedly consider the relations between costs and all of the various factors that might affect costs. While this might be interesting, in addition to being a very useful and worthwhile endeavor, it is not one of the objectives of this study; and neither the time nor resources for such a task are presently available. For the purposes of this study, we will concern ourselves primarily with weight and distance output dimensions, not only because they are the most important variables but because data on these variables can be obtained by the approach of this study while data on the other variables cannot.[3] The cost of terminal activities such as loading, insofar as they are affected by variations in weight, will also be considered because the data can be expected to include some of these costs and therefore to influence the relations obtained. We will consider the expected relationship between transportation costs and these variables from the viewpoint of what might be called a "typical" transportation firm which hauls frozen vegetables.

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[1] While generalization is not practical for areas as large as the United States, this is not true for selected routes. For example, see Smith, op. cit.

[2] It should be noted that this is in contradistinction to the usual practice of designating output as ton-miles--that is, total tons times total miles. The reasons for this will be deferred until we have developed the necessary cost relations. Infra, p. 20.

[3] Weber, op. cit., p. 41.

For this typical firm, we shall make certain specifications and assumptions in addition to those above which may be more or less justified in reality. In addition to abstracting from the topographical factors mentioned above, we shall assume that the average speed of movement is constant at some level. Further, we shall assume that each firm has a given amount of equipment in terms of hauling vehicles and terminal facilities which does not vary in quantity nor with output for the time period under consideration. It will also be assumed that this plant and equipment are used for the full amount of time available.[1/] And while each firm is thought of as consisting of a number of units of equipment, each of these units is assumed to be identical.[2/]

In the following discussion we shall first consider the relationships for a firm consisting of one hauling unit and the requisite terminal facilities and then expand this to a firm consisting of multiple units. We may begin by breaking the total cost (TC) into three cost categories through the use of an accounting identity in order to facilitate the exposition. There are (1) the plant and equipment or fixed cost (FC) which include the hauling vehicles and terminal facilities that do not vary with output in the short run; (2) the terminal costs (LC) which include all the costs of loading, etc.; and (3) the cost associated with the actual movement of the load or transport costs (tC) which include the cost of fuel, labor, etc., and the user cost items. Fixed costs will affect the level of costs in the short run but will not vary with distance and other factors. Our main interest is in the terminal and transport costs and the relationship between these costs and the output variables, weight and distance.

[1/] This assumption excludes the question of whether a given output will be produced by operating at one rate of output for a given number of hours or at a faster rate for a smaller number of hours.

[2/] Some justification for this assumption was found in conversation with officials of transportation firms that transported frozen vegetables. It was indicated that single trailers and tractors were all about the same size, at least for all but the small trucking firms. There is some variation in size and initial equipment cost for double trailers, however. For transport by rail, mechanically refrigerated cars are used for frozen vegetables, and it was indicated that these were of uniform size.

Terminal costs probably vary with size of load and increase with increases in weight. This cost behavior will result from the increase in labor required if other inputs are held constant. Should this type of input variation occur (it seems reasonable for this type of activity), we could expect the law of diminishing returns to be operative because this activity represents an increase in the ratio of variable to fixed factors as weight increases. Or, in other words, there is intensification on the fixed factors. Whether all three of the traditional "stages" of conventional economic theory are possible is a matter for empirical determination.[1/] However, it seems reasonable to expect that variable loading cost per unit of weight would be less for larger shipments such as carload lots than for less-than-carload lots.[2/] This suggests that average variable cost is decreasing for some range of load size, which implies that the marginal cost is below the average variable cost in that range. But this does not necessarily mean that total variable cost is increasing at a decreasing rate in that range; more reasonably, it could be increasing at an increasing rate.[3/] There is also likely to be some fixed or constant terminal

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[1/] It may well be that the relationship is nearly linear for ranges of weight experienced in practice. For a discussion of the stages of production, see:

> Richard H. Leftwich, The Price System and Resource Allocation (New York: Rinehart and Company, 1955), pp. 106-109.
>
> Yair Mundlak, "A Note on the Symmetry of Homogeneous Production Function and the Three Stages of Production," Journal of Farm Economics, Vol. XL, No. 3 (August, 1958), pp. 756-761.

[2/] For example, consider a hypothetical case where a carload is made up of, say, 15 individual shipments weighing two tons each. Keeping these shipments separated through the loading process is almost certain to require more man-hours per ton than a similar single shipment of 30 tons, not to mention the additional paper work, etc., prior to loading.

[3/] The latter requires only that there be a previous output range in which total variable cost increases at a decreasing rate, which appears plausible if individual shipments are very small, but it does not require observations in this range in a practical situation. Similarly, increasing average variable cost may be possible and exist in fact, but increasing average variable cost may or may not be observed in practice. This could occur if the data were observations on average cost in a range that was to the left of the minimum average cost. Moreover, it is not economically irrational for a firm under monopolistic conditions and free entry to operate in a range of decreasing average cost; see Leftwich, op. cit., p. 270.

cost regardless of the size of the load. A priori, distance is not expected to affect terminal costs in any systematic manner.

Transport costs (tC) will probably be affected by most of the topographical factors mentioned previously, but they will be particularly influenced by distance and weight. For a given size hauling vehicle, holding the variables other than distance constant, we would expect the total tC to increase at a constant rate as distance increases.1/ The rationale for such a relationship is that the proportion of factors remains constant as distance increases, and, consequently, there is no intensification on the fixed factors. That is to say, fuel, labor, etc., are not expected to vary on a per mile basis from one mile to the next.

Variations in transport costs resulting from variations in load weight, however, represent a different case. In essence, we are asking the question of how the above-per-mile cost varies as weight varies. To begin with, there would be some constant cost associated with tC representing the cost of the trip with no load weight. Total tC would increase as weight increased as a result of the increases in variable inputs, such as fuel, holding distance, speed, and vehicle size constant.2/ This variation also represents a change in the proportion of the variable factors to the fixed inputs, and consequently, we might expect the law of diminishing returns to be operative.3/ In practice, one would also expect a range of increasing average variable cost as physical capacity of the vehicle was approached. Whether a range of increasing average cost is obtained in practice is another empirical question which would depend

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1/ The initial cost involved in starting the load to move at the assumed constant speed is disregarded.

2/ Smith, op. cit.

3/ Again, the question of whether all three of the traditional stages are present or possible is a matter of empirical fact. However, considering the large capacity of the freight vehicles under consideration relative to the potential weight variation, it is not unlikely that all three stages could be demonstrated, at least experimentally. Actually, with such potential weight variation relative to capacity, it would not seem unreasonable in practice to expect a range of increasing average product. Whether this occurs in stage one or stage two depends on the nature of the production function (see Mundlak, op. cit.); but the often repeated comment that the railroad industry is one of "decreasing costs" would certainly be consistent with the observation of increasing average product and decreasing average variable cost if decreasing cost is interpreted as increasing returns to scale.

on the competitive nature of the industry and the demand faced by the firm; with a negatively sloped demand curve facing the firm and free entry into the industry, it is unlikely in a long-run, static framework.[1]

In summary, of the case of one vehicle and the requisite terminal facilities considered above, on a priori grounds we would expect the following potential cost relationships.[2] First, there will be some total fixed cost (FC) for equipment and other items. Second, the total terminal and loading cost (LC) will be an increasing, nonlinear function of weight and will have some constant cost associated with it regardless of weight. Terminal cost is not expected to be functionally related to distance. Third, total transport cost (tC) is expected to be an increasing linear function of distance for any given weight. The slope coefficient of this linear function is expected to be an increasing, nonlinear function of weight. Utilizing our previous accounting identity, we may summarize this as follows:

$$TC' = FC' + LC' + tC' \qquad (1)$$

$$LC' = a'_o + g(W)' \qquad (2)$$

$$tC' = \beta' D; \; \beta' = b'_o + f(W)' \qquad (3)$$

where

D = distance in miles.

W = weight.

' = relation is for a single hauling unit and the requisite terminal facilities.

a'_o = positive constant.

b'_o = positive constant.

$g(W)'$ = increasing, nonlinear function of W.

$f(W)'$ = increasing, nonlinear function of W.

Combining these, we obtain the following functional relation:

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[1] Leftwich, op. cit., pp. 267-270.

[2] It should be emphasized that by "potential" it is meant that such behavior could possibly be demonstrated experimentally, and it is not meant to imply that such behavior exists in practice.

$$\begin{aligned} TC' &= FC' + a'_o + g(W)' + [b'_o + f(W)']\, D \\ &= FC' + a'_o + g(W)' + b'_o D + f(W)' D. \end{aligned} \qquad (4)$$

Disregarding the fixed cost component (FC') of (4) for illustrative convenience, the above cost function is represented as a three-dimensional cost surface in Figure 1 where g(W)' and f(W)' are assumed to include all the ranges of a conventional cost curve.

We shall now consider the problem of a firm consisting of multiple equipment units, retaining our earlier assumption that the equipment units are identical. Essentially, this is a problem of determining the optimum use of identical machines. This section will necessarily be brief because we shall utilize a previous development by French et al., which deals with this particular problem.[1] In doing so, we will assume that the cost behavior represented in Figure 1 is applicable for single equipment units. The solution involves determining the minimum total variable cost curve for any given rate of output by varying the number of equipment units where the inputs for each unit vary in the continuous manner assumed by conventional theory. The authors illustrate the situation for two machines in terms of an isocost-isoquant diagram. Then, they extend the discussion to include multiple-equipment units, as indicated in the following quotation:

> "A 'kink' or discontinuity occurs . . . where the second machine comes into use. But to obtain minimum costs, the two machines are used equally. If a third machine is added, all three will be used at the same rate (total output will be the sum of the output with each machine) and another discontinuity will occur . . . where this machine is brought into use. Thus, when output is varied by varying the use of identical machines, the variable cost function for the plant will be discontinuous even though continuous variation is possible for each machine. However, as the number of equipment units is increased, the total cost function approaches linearity."[2]

If this result holds for our present case, we might reasonably infer that the LC function and the variable 8 for multiple units could be approximately represented by linear functions considering the relatively large number of

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[1] B. C. French, L. L. Sammet, and R. G. Bressler, "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," Hilgardia, Vol. 24, No. 19 (July, 1956), pp. 551-553.

[2] Ibid., p. 551.

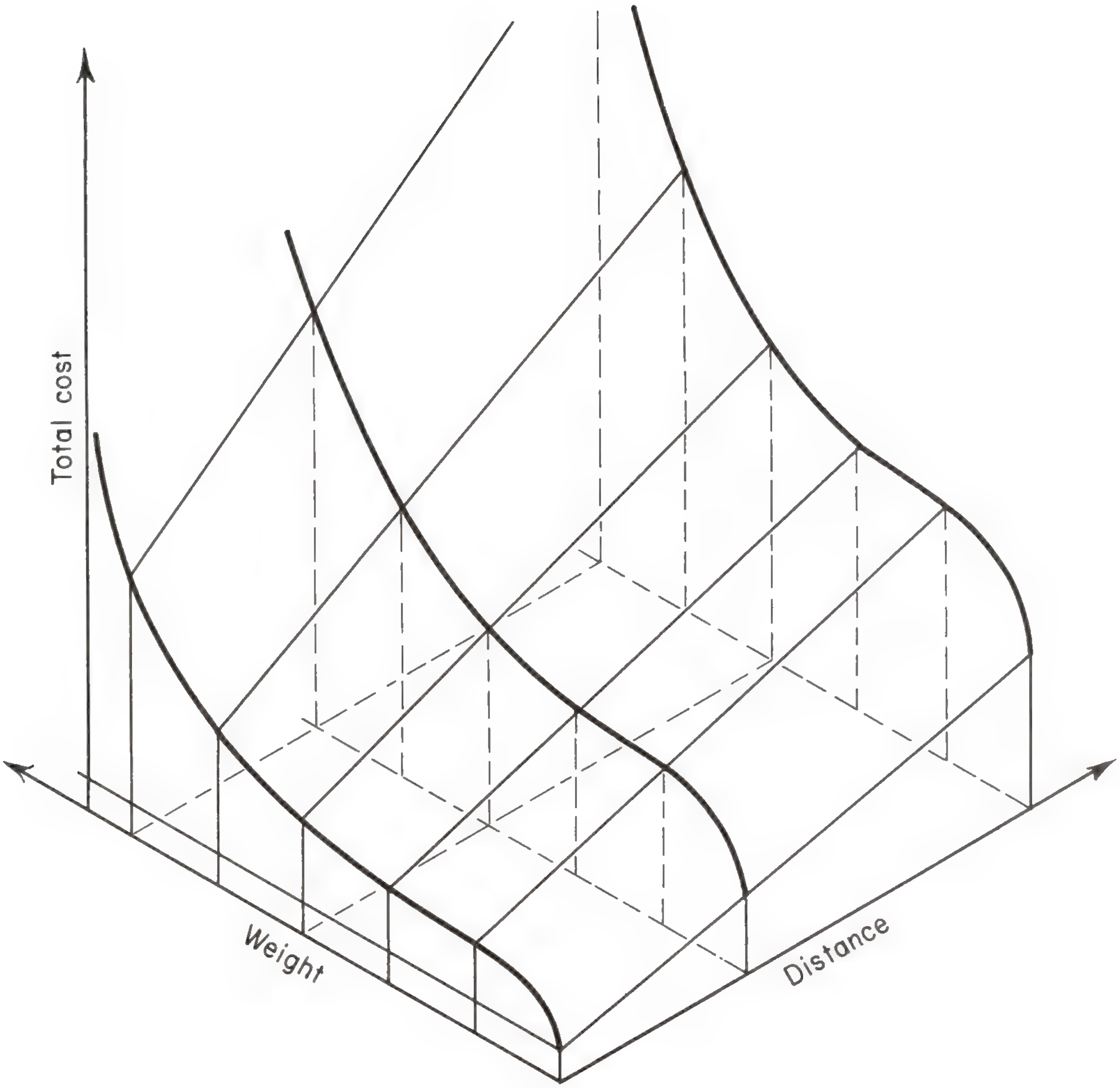

FIGURE 1. Diagrammatic Representation of a Hypothetical Total Cost Surface for One Vehicle and the Requisite Terminal Facilities

equipment units operated by most of the transportation firms under consideration. The problem of double trailers for trucking firms might be considered separately in a similar manner. The main difference would be the level of fixed costs of the equipment. Assuming that the above is not a gross misrepresentation of the case at hand, our resulting total cost function for a firm with multiple-equipment units would be of the following form:

$$TC = FC + a_o + a_1W + [b_o + b_1W] D = FC + a_o = a_1W + b_oD + b_1WD \qquad (5)$$

where the variables W and D are defined as before, and a_o, a_1, b_o, and b_1 are positive constants.

It is recognized that this cost function is a simplification, abstracting from much of the detailed aspects of any existing transportation firm in addition to abstracting from certain theoretical aspects that could possibly result in some slight curvilinearity in the weight dimension. But in the absence of empirical evidence on the input-output relationships, it appears as reasonable as any other form and more convenient than most as a starting point for the purpose of our study.

There is some empirical evidence cited earlier, however, which supports the form of the relation finally derived above.[1/] Indeed, it is surprising that the similarity is so great when one considers the diversity of procedure in arriving at the result in each case. At any rate, we shall use this basic form of the cost function as an approximation in fulfilling our initial objective of this discussion which was that of specifying a priori the functional relationship expected between cost and the output variables, weight and distance.[2/]

[1/] U. S. Congress, House, *Regionalized Freight Rates: . . .*, pp. 61-66.

[2/] The distinction made earlier (*supra*, p. 13) between the use of the output dimensions of weight and distance and the use of ton-miles can now be clarified. It was observed at several places in the literature that ton-miles was used as a single measure of output. A moment's reflection on our discussion of the a priori relationship between costs and the variables, weight and distance, should make it obvious that such a use of ton-miles is conceptually correct only under very special circumstances. Specifically, the necessary restriction is that tons and miles be "perfect substitutes" in terms of cost. For example, 40 tons transported 100 miles must be equivalent in cost to 20 tons transported 200 miles. This will occur where the total cost surface is completely linear with respect to distance and weight, separately and in combination. That is, the isocosts will have to be linear. Even then, if the coefficients of cost with respect to each of these variables separately are not identical, either miles or weight will have to be multiplied by some constant scalar in order to come out with equal costs. It is doubtful that such circumstances are often obtained in practice.

One final task remains in this discussion. Transfer charges are usually quoted in dollars per unit of weight, which correspond to an average unit cost. However, our previous functional cost relationship is in terms of total costs. Therefore, we should convert this to an average cost per unit of weight by dividing both sides of the total cost function (5) by weight, as follows:

$$\begin{aligned}\text{Average C/u.w.} &= \frac{TC}{W} = \frac{FC}{W} + \frac{a_o}{W} + \frac{a_1 W}{W} + \frac{b_o D}{W} + \frac{b_1 WD}{W} \\ &= a_1 + \frac{FC}{W} + \frac{a_o}{W} + \frac{b_o D}{W} + b_1 D\end{aligned} \tag{6}$$

where C/u.w. = cost per unit of weight.

It will be useful for our later analysis to make explicit the relations of cost per unit of weight to the variables, weight and distance, separately. Holding weight constant at some level, say W_c, we have the following relation of cost to distance:

$$\text{C/u.w.}\big|W_c = a_1 + \frac{FC}{W_c} + \frac{a_o}{W_c} + \frac{b_o D}{W_c} + b_1 D. \tag{7}$$

This reduces to the linear relation:

$$\text{C/u.w.}\big|W_c = A + BD \tag{8}$$

where

$$A = a_1 + \frac{FC}{W_c} + \frac{a_o}{W_c} > 0.$$

$$B = \frac{b_o}{W_c} + b_1 > 0.$$

Similarly, holding distance constant at some level, say D_c, we obtain the following functional relation of cost to weight:

$$\begin{aligned}\text{C/u.w.}\big|D_c &= a_1 + \frac{FC}{W} + \frac{a_o}{W} + \frac{b_o D_c}{W} + b_1 D_c \\ &= a_1 + b_1 D_c + \frac{FC}{W} + \frac{a_o}{W} + \frac{b_o D_C}{W}.\end{aligned} \tag{9}$$

This reduces to the following decreasing nonlinear function:

$$C/u.w.\Big| D_c = A^* + \frac{B^*}{W} \qquad (10)$$

where

$A^* = a_1 + b_1 D_c$ and $a_1,\ b_1 > 0.$

$B^* = FC + a_o + b_o D_c$ and $a_o,\ b_o > 0.$

Empirical Results

Introductory Discussion

A relatively large number of equations have been derived from the data. In order to reduce confusion and gain perspective, we shall preface this section with a general discussion of what was actually attempted and the results obtained. Subsequently, we shall discuss in more detail the equations obtained from the data for motor carrier and rail. This will be followed by a discussion of the attempts to derive combined relationships for use in estimating transfer charges for frozen vegetables.

Empirical estimates of transfer charge relationships were largely based on the expected relationships between costs, weight, and distance as expressed in equations (6), (8), and (10).[1] Deviations from this specified form resulted from (1) utilization of knowledge about how rates are established in practice and information from previous studies of the relationship of rates to distance and (2) a consideration of convenience, both in statistical fitting and in the later use of functions for estimation of charges.

The a priori cost relations specified that cost is an increasing linear function of distance and a decreasing nonlinear function of weight. Within the limits of these specifications, several functional forms may be used to incorporate the basic characteristics, some of which are more difficult to fit statistically than others. All of the forms used in this study were linear, either in the original variables or the transformed variables. As a first approximation to these basic characteristics, functions representing cost as a simple linear function of both weight and distance were used. Figure 2 is a diagrammatic representation of a hypothetical cost surface of this form. At the same time, simple functions containing the log of weight were used to allow nonlinearity with respect to the weight variable as indicated by the a priori specifications. Subsequently, the functions were altered in order to (1) achieve a closer approximation to the a priori specifications and (2) incorporate the assertion of nonlinearity with respect to distance.

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[1] *Supra*, p. 21.

Two samples of data were envisioned initially--namely, rail and truck. But the fact that part of the rail data did not contain refrigeration charges dictated that the rail data be further divided into two more samples. Sample A consists of data which include refrigeration charges, and Sample B consists of data on basic freight rates excluding refrigeration charges. While the latter is not a measure of transfer charges per se, it was felt that analysis of these data would still be beneficial.1/ Primary interest, in terms of the objectives of this study, is in the relationships derived from the total observations in each of the above samples. To obtain more information and insight about these relations, the data were also subdivided by weight categories and equations obtained for each category to the extent possible.

A preliminary plotting of some of the data also indicated that there might be some variation in charges related to the direction of travel. With the primary purpose of ascertaining whether any hypotheses concerning such variation of charges were suggested by the data, each of the three initial samples was classified by direction of travel to the extent possible; and separate equations were obtained for the three categories: (1) E-W (east to west), (2) W-E (west to east), and (3) Other (all directions other than E-W and W-E).

In general, the statistical results were favorable. The squared correlation coefficient, R^2, varied considerably between some classifications, but it was relatively high (1) considering that the data consist of commodity rates for trucks and a mixture of commodity and class rates for rail and (2) in view of assertions such as the following statement concerning commodity rates from an extensive study of rail freight rates:

1/ In fact, Sample A data are not transfer charges in the strictest sense because certain loading and cartage charges, usually borned by the shipper, are not included. However, an adjustment is made later to account for this.

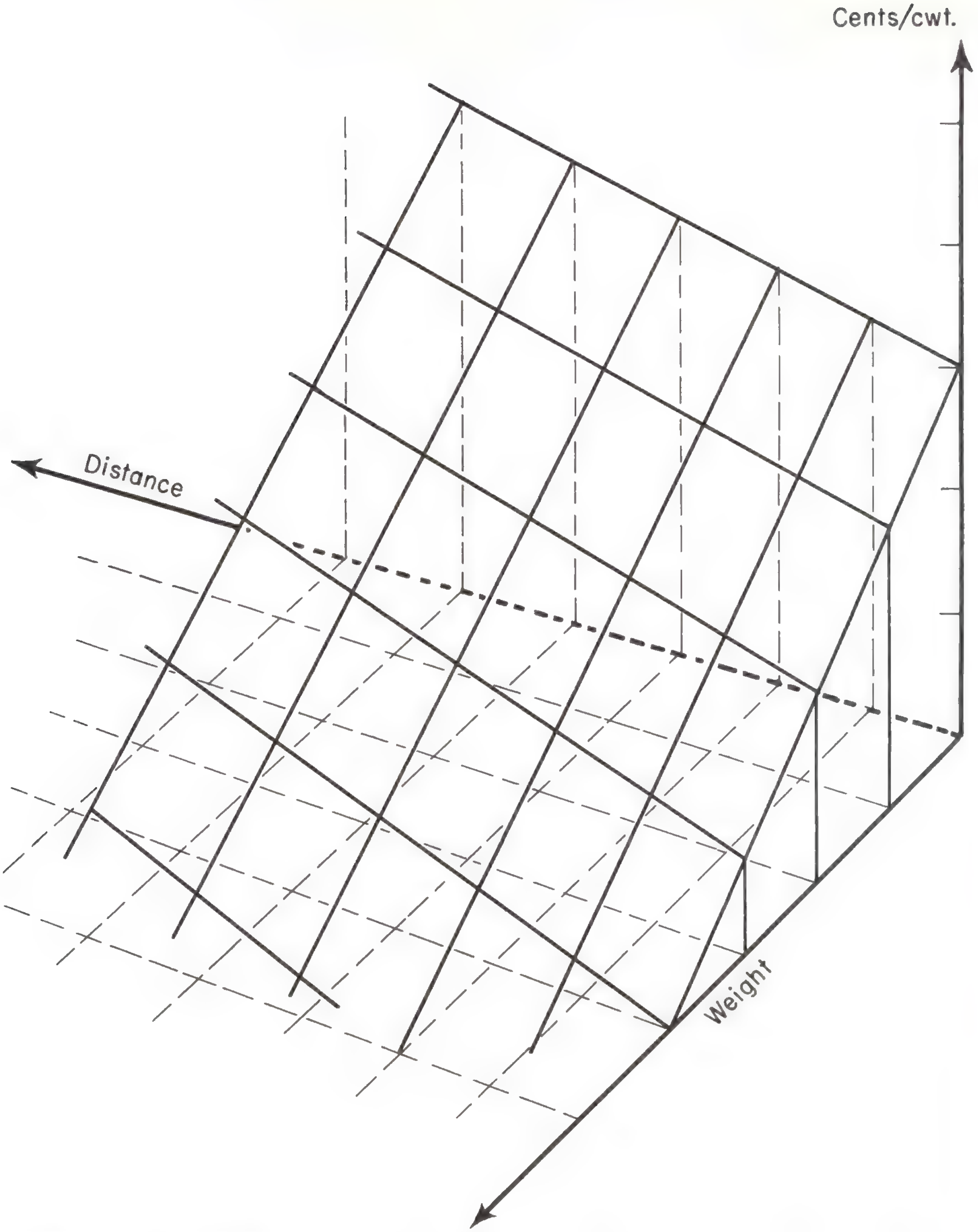

FIGURE 2. Diagrammatic Representation of Transfer Charge Function Which Is Linear with Respect to Both Weight and Distance

> "Because of the weight given to such factors as market competition and equalization of competitive opportunity, there is often no discernible rate pattern, and even less frequently is there any consistent relationship to transportation costs. . . . Competitive factors appear to be given greater weight than in the case of the class-rate structure. Because of the multiplicity of these rates and the variations encountered, it has not been feasible to develop quantitative overall measures of differences in the average levels of published commodity rates."[1]

With few exceptions, the coefficients of the various parameters were statistically significant at the .01 level.[2] Added support for this statistical criterion was supplied by a regression fitted to the two independent variables, weight and distance, which demonstrated a lack of correlation.[3]

Since statistical measures seldom provide a complete basis for choosing between comparable alternative formulations, economic plausibility and the a priori cost specifications were also employed as choice criteria. When these criteria failed to rank alternative formulations unambiguously, the practical criteria of convenience and simplicity of form were adopted. Equations were finally selected for each mode of transport which were thought to be adequate representations of the quoted transfer charges by that mode of transport. Utilizing data which showed the distribution of shipments between rail and truck, the rail and truck functions were used to derive combined transfer charge functions that might be used in estimating transfer charges for frozen vegetables. We now turn to a more detailed discussion of the results considering first those for trucks.

Motor Carrier Results

The equations derived from motor carrier data are presented in Table 1. Seven different equation forms (equations 1 through 7) were fitted to the total number of observations--486. Three of these forms were used in each of three separate weight categories (equations 20 through 28). The main consideration is the form of the functions with respect to the variables, weight and distance.

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[1] U. S. Congress, House, Report on Interterritorial Freight Rates . . ., p. 342.

[2] Where the signs of the coefficients were specified by the a priori relationships, a one-tailed statistical test was used; where the signs were not so specified, a two-tailed test was used.

[3] See equation 30, Table 1, p. 26.

TABLE 1

Transfer Charge Functions and Supplementary Equations Showing the Relationship Between Highway Miles and Air Miles and Between Weight and Distance Derived from Motor Carrier Data for Frozen Vegetables

Equation form[a]	Number of obser-vations	R^2	Constant term	Regression coefficients		t-ratios	
				Distance	Weight	Distance	Weight
Overall equations							
1. $C_T = f(X_1, X_3)$	486	0.745	226.870	0.143	- 5.470	33.130	-15.770
2. $C_T = f(X_1, \log X_3)$	486	0.762	517.320	0.139	- 306.885	33.251	-17.374
3. $C_T = (\log X_1, \log X_3, X_3)$[b]	486	0.752	269.964	205.140	- 536.679[b] 4.196	31.566	- 8.334[b] 3.429
4. $C_T = f(\log X_1, \log X_3)$	486	0.746	76.980	207.329	324.723	31.710	
5. $C_T = f(X_1, X_1^2, \log X_3)$	486	0.776	496.412	0.216 $- 0.377(10^{-4})$	312.514	14.991 - 5.563	-17.170
6. $C_T = f(X_1, \frac{1}{X_3})$	486	0.755	- 11.989	0.135	2,429.306	31.688	16.762
7. $C_T = f(X_1, \frac{1}{X_3}, \frac{X_1}{X_3})$	486	0.758	23.289	0.109	1,526.139 0.661[c]	9.456	3.893 2.477[d]
Direction of travel							
8. $C_T = f(X_1, X_3)$ W-E	193	0.733	332.325	0.103	- 7.246	14.314	-15.415
9. $C_T = f(X_1, \log X_3)$ W-E	193	0.736	630.274	0.100	- 349.948	13.925	-15.553
10. $C_T = f(\log X_1, \log X_3)$ W-E	193	0.734	94.952	220.580	- 357.773	13.861	-15.928

(Continued on next page.)

TABLE 1--continued.

Equation form[a]		Number of observations	R^2	Constant term	Regression coefficients		t-ratios	
					Distance	Weight	Distance	Weight
11. $C_T = f(X_1, \frac{1}{X_3})$	W-E	193	0.716	26.699	0.098	2,631.819	13.060	14.547
12. $C_T = f(X_1, X_3)$	E-W	107	0.576	181.023	0.133	- 3.370	11.807	- 2.854
13. $C_T = f(X_1, \log X_3)$	E-W	107	0.580	397.883	0.134	- 215.599	11.889	- 3.068
14. $C_T = f(\log X_1, \log X_3)$	E-W	107	0.536	-256.389	237.489	- 157.700	10.863	- 2.148[e]
15. $C_T = f(X_1, \frac{1}{X_3})$	E-W	107	0.584	- 4.122	0.134	2,502.714	11.953	3.242
16. $C_T = f(X_1, X_3)$	Other	186	0.793	124.697	0.186	- 2.958	25.278	- 6.158
17. $C_T = f(X_1, \log X_3)$	Other	186	0.811	375.955	0.187	- 233.360	26.685	- 7.653
18. $C_T = f(\log X_1, \log X_3)$	Other	186	0.724	6.594	172.839	- 217.138	20.712	- 5.881
19. $C_T = f(X_1, \frac{1}{X})$	Other	186	0.814	- 45.990	0.189	2,300.606	27.174	7.860
Weight categories (Less than 27M)								
20. $C_T = f(X_1)$		192	0.899	51.341	0.219		41.045	
21. $C_T = f(\log X_1)$		192	0.738	-627.000	306.602		23.157	
22. $C_T = f(X_1, X_1^2)$		192	0.899	48.200	0.228 - 0.392(10^{-5})		11.623 - 0.436[f]	

(Continued on next page.)

TABLE 1--continued.

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients		t-ratios	
				Distance	Weight	Distance	Weight
(27M-33M)							
23. $C_T = f(X_1)$	248	0.649	84.865	0.103		21.331	
24. $C_T = f(\log X_1)$	248	0.714	-286.168	163.490		24.776	
25. $C_T = f(X_1, X_1^2)$	248	0.733	36.567	0.231 - 0.624(10^{-4})		15.277 8.793	
(Greater than 33M)							
26. $C_T = f(X_1)$	46	0.632	63.929	0.160		8.697	
27. $C_T = f(\log X_1)$	46	0.705	-386.585	202.815		10.261	
28. $C_T = f(X_1, X_1^2)$	46	0.693	8.791	0.376 0.016(10^{-2})		4.963 - 2.924	
Airline-highway distance							
29. $X_1 = f(X_2)$	486	0.992	- 0.510	0.801		248.187	
Distance-weight relationship							
30. $X_1 = f(X_3)$	486	0.005	726.852		-4.721		0.982[f]

(Continued on next page.)

TABLE 1--continued.

a/ C_T = charges per hundredweight.

X_1 = airline distance, miles.

X_2 = highway distance, miles.

X_3 = minimum load weight, thousand pounds.

log = logarithm to the base 10.

M = thousand pounds.

W-E = west to east; E-W = east to west; and Other = all directions other than E-W and W-E.

b/ The upper number corresponds to log X_3 and the lower number, to X_3.

c/ Coefficient of the variable $(\frac{X_1}{X_3})$.

d/ t-ratio of the coefficient of the variable $(\frac{X_1}{X_1})$.

e/ Significant at the .05 level but not at the .01 level.

f/ Not significant at the .05 level or above.

Therefore, the overall equations will be discussed separately with respect to distance and then with respect to weight. Subsequently, the equations derived from the subclassifications concerning different directions of travel will be discussed briefly.

Highway Versus Airline Distance.--Two equations of identical form were fitted to the total observations and to each subclassification, one containing highway mileage as a measure of distance and the other containing airline mileage.[1/] In addition, an equation relating airline distance to highway distance was obtained from the distance measurements for motor carrier data. In all cases, R^2 is higher for equations using highway mileage than for the corresponding equations using airline mileage. The coefficients with respect to distance are significant at the .01 level in all cases. The regression of the two distance measurements--29--shows that airline mileage is approximately 80 percent of highway mileage on the average (the intercept term is near zero). Although these results show that some loss of explanatory power is incurred by using airline distance, the loss is compensated by the advantages of this simplification, as expressed earlier in the discussion of distance measurement.[2/] Consequently, all subsequent equations were derived using airline miles as a measurement of distance.

Form of the Relation with Respect to Distance.--The primary consideration regarding transfer charges per hundredweight as a function of distance is that of linearity versus curvilinearity. A priori cost specifications designate the former, while previous studies suggest the latter. One linear form and two curvilinear forms were used, one of the latter being a logarithmic transformation of distance and the other, a quadratic in distance.

Comparison of the log form with the linear on statistical measures shows the distance coefficients to be significantly greater than zero at the .01 level for both forms in all such comparisons. R^2 is higher for the linear form than for the log form in five comparisons (2, 4), (9, 10), (13, 14), (17, 18), and (20, 21) and lower in two cases (23, 24) and (26, 27). Comparison of the linear form with the quadratic form reveals the coefficients of the linear form to be significant (.01 unless otherwise stated) in all cases, while the quadratic form has significant coefficients in all but one case, equation 22, in

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[1/] These equations appear in Appendix Table 6, p. 86.

[2/] Supra, pp. 10 and 11.

which the coefficient of distance squared is not significant at the .30 level. In this case, the hypothesis of curvilinearity in the postulated form is rejected. Strictly speaking, a comparison of the coefficient of determination between the linear and quadratic equations should be made on the basis of the adjusted R^2 ($\bar{R}^2$). Making this comparison, $\bar{R}^2$ for the quadratic form is higher in three cases (2, 5), (23, 25), and (26, 28) and lower in the case of the nonsignificant coefficient noted above (20, 22).

On economic considerations, a comparison of the log form with the linear form with respect to distance reveals a negative constant term for the log form in four cases--14, 21, 24, and 27. This is particularly relevant in view of the fact that this occurs well within the range of the data. Actually, equations 3 and 10 have negative intercepts for values of weight occurring within the range of the data. A comparison of the linear form with the quadratic form shows the quadratic form to be decreasing within the range of the data for two cases--25 and 28--and beyond the range of the data in two cases--5 and 22. This is shown in Figure 3A for equation 5. Although transfer charges, as depicted in equation 5, begin to decrease at long distances (charges reach a maximum at approximately 2,867 air miles), this occurs beyond the range of the data. From a practical viewpoint, the linear function may be the most convenient, particularly in deriving a combined transfer charge function.

In summary, concerning the form of the functions with respect to distance, the hypothesis of an increasing function is consistently supported. There is no positive evidence that the function increases at an increasing rate. The evidence is not sufficient to conclude that the relationship increases at either a constant or a decreasing rate with respect to distance. Although curvilinearity cannot be rejected in general, there is some evidence against the particular nonlinear forms employed. On both statistical and economic considerations, the evidence is sufficient to exclude the form containing the log transformation of distance used in this study.

The rejection of the quadratic form in one case and the decreasing segment of these equations which occurred within the range of the data in two cases offer evidence against this particular form. On intuitive grounds, the lower t-ratios of the coefficients of distance in the quadratic form might be considered also. However, one must weigh this evidence against the greater explanatory power of the quadratic equations as indicated by the R^2 values. For the overall equation 5, the decreasing segment is quite likely beyond the range

FIGURE 3A. Transfer Charge Relationships Derived from Motor Carrier Data Showing the Relationship of Charges (Cents Per Hundredweight) to Distance (X_1), Holding Minimum Load Weight (X_3) Constant

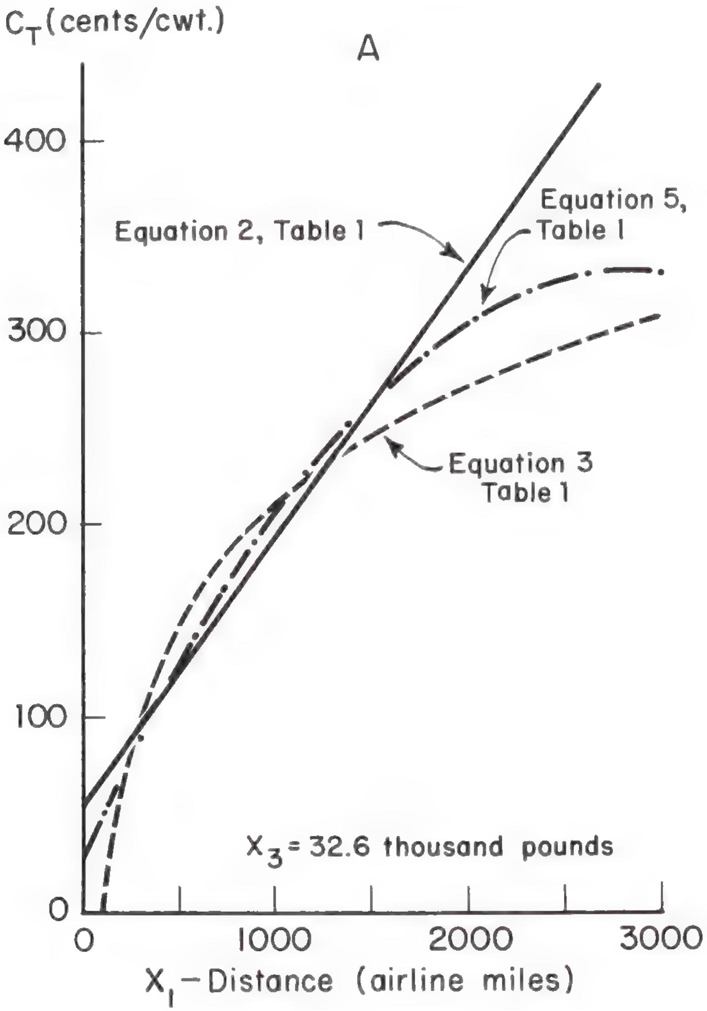
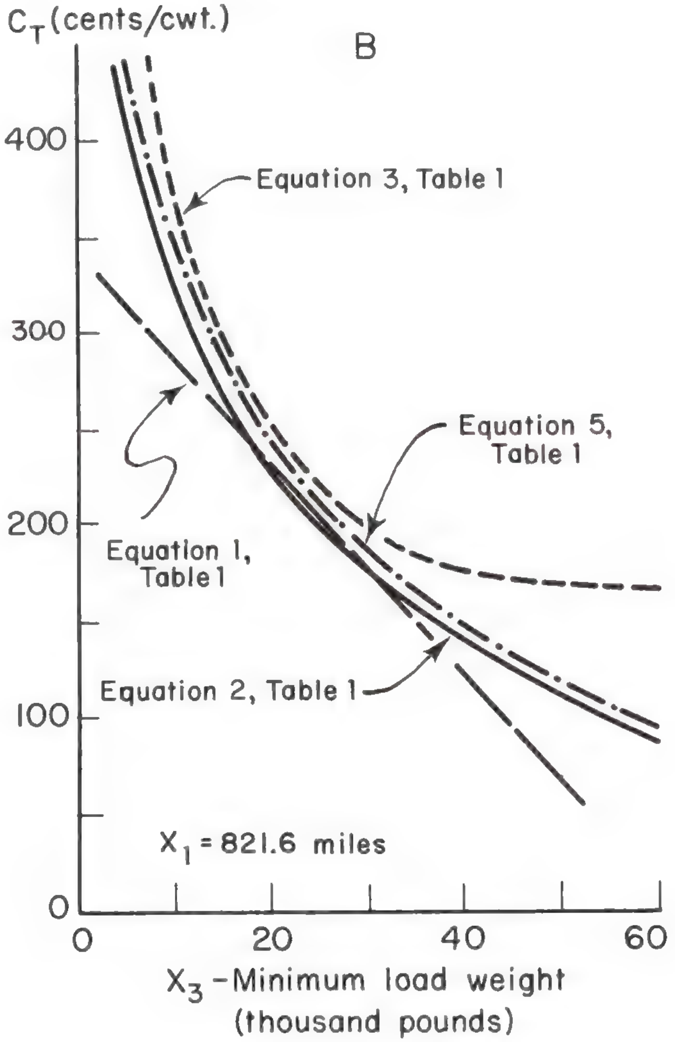


FIGURE 3B. Transfer Charge Relationships Derived from Motor Carrier Data Showing the Relationship of Charges (Cents Per Hundredweight) to Minimum Load Weight (X_3), Holding Distance (X_1) Constant



for which estimated transfer charges are required. The linear form, specified by a priori cost considerations, consistently gave positive results although it had slightly lower explanatory power than the quadratic equations. In view of this, the selection of one of the equations--for instance, 2 or 5--depends on one's subjective weighing of the greater explanatory power and inconsistent results of the quadratic form against the lower explanatory power and consistent results of the linear equations which are based on some a priori specifications.

Weight Considerations.--Previous studies dealing with the estimation of transfer charges have not considered the weight variable explicitly. Theoretically, if transfer charges are a monotonically decreasing function of weight as postulated and if transfer charges are to be minimized, the implication is to choose the largest minimum load weight available for any given shipment. Transfer charges would then be estimated for all distances by setting the minimum load weight in the derived equation at this maximum. Another consideration, which concerns the effect on the coefficients of distance, will be discussed later.

The a priori cost specifications served as a basis for postulating various functional forms with respect to weight to be fitted to the data. Five different formulations were fitted to the total group of observations, three of which were then used for the three subclassifications dealing with the direction of travel. The formulations consisted of a linear form, 1; a logarithmic transformation of weight, 2; a combination of these two, 3; a reciprocal transformation of weight, 6; and a reciprocal transformation of weight plus the reciprocal of weight multiplied by distance, 7.[1] Equation 1 was used to incorporate the single specification of a decreasing function of weight, and equation 2 was formulated to allow for both the decreasing and nonlinearity specifications. The only purpose of equation 3 was to investigate the possibility of an increasing segment of the relationship in question. Equation 6 was used to achieve a closer approximation to the a priori specifications and for a comparison with equation 7 to determine the effects on the distance coefficient of excluding the last term in equation 7. Equation 7 incorporated all of the a priori specifications contained in the relationship (6).[2]

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[1] See Table 1, p. 26.

[2] Supra, p. 21.

Considering the statistical measures with respect to weight, all of the coefficients are significant at the .01 level, except the coefficient of equation 14 which is significant at the .05 level. Comparing the equations which are linear in weight with the corresponding equations having a log transformation reveals the R^2 to be higher in all comparisons (1, 2), (8, 9), (12, 13), and (16, 17) for the log transformation form. Comparison of the linear form with the form having a reciprocal transformation shows the R^2 to be greater for the reciprocal form in three cases (1, 6), (12, 15), and (16, 19) and smaller in one case (8, 11). In comparing the reciprocal transformation form with the corresponding log transformation form, the R^2 for the log form is greater in two cases (2, 6) and (9, 11) and smaller in two cases (13, 15) and (17, 19). A comparison of equation 2 with equation 7 indicates that the adjusted R^2 for 2 is greater than for 7 by .004. Focusing on the equations 6 and 7, the adjusted R^2 for 7 is higher by .003, and it should be noted that the coefficient of $\left(\frac{X_1}{X_3}\right)$ is significant at the .01 level in equation 7. The nonsignificant coefficient of 14 appears to result more from the log transformation of distance in that equation than from the log transformation of weight. This is indicated by comparing 13 with 14. The nonsignificant coefficient seems of little relevance in this case, and it is concluded that motor carrier transfer charges are a decreasing function of weight.

While the hypothesis of linearity is not rejected per se, statistical measures furnish more support for the hypothesis of a curvilinear relationship of transfer charges to weight than for the linear relation. This is consistent with the a priori specifications; and, barring any economic or practical reasons that outweigh these statistical considerations, we shall exclude the postulated linear relationship of charges to weight and subsequently consider only the log and reciprocal forms for use in estimation of transfer charges. Although equation 4 has an increasing segment with respect to weight, this occurs considerably beyond the range of the data as indicated in Figure 3B. Equations 6 and 7, which are used to approximate the a priori specifications, are shown in Figures 4A and 4B.

Any omission of the weight variable is a specification error in the statistical sense; and, depending upon the relationship of weight and distance in the true specification, its exclusion may result in biased estimates of the coefficient with respect to distance. Consequently, the charges estimated with

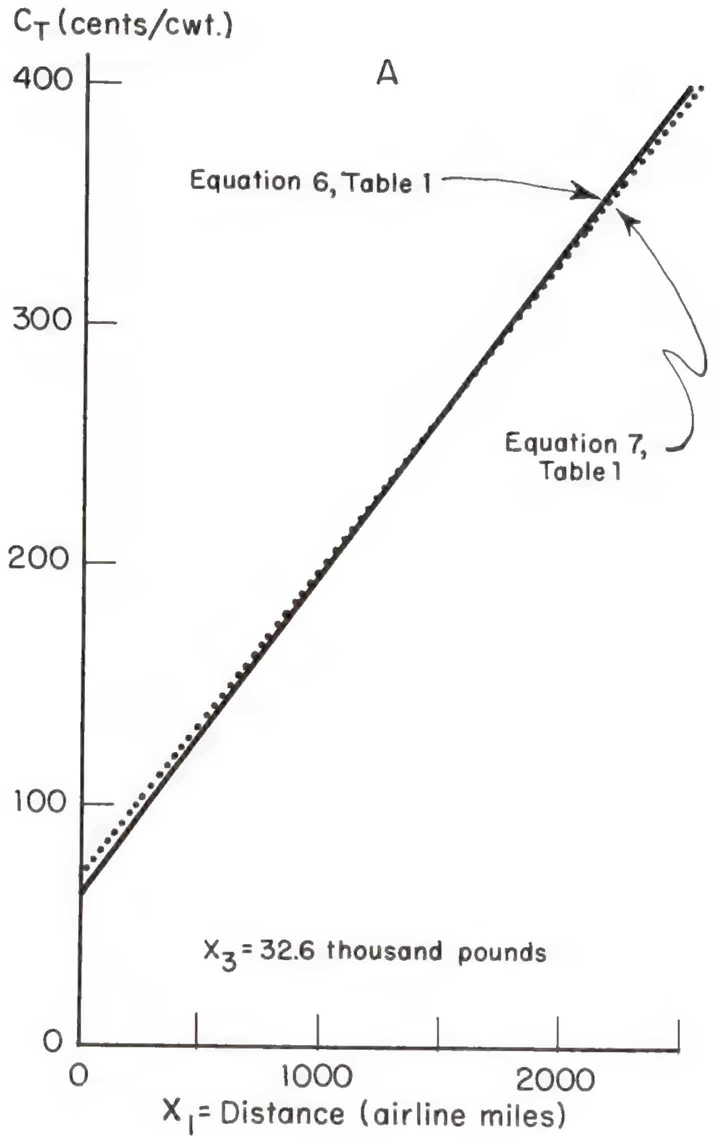

FIGURE 4A. Equations Derived from Motor Carrier Data Showing the Relationship of Charges (Cents Per Hundredweight) to Distance (X_1), Holding Weight (X_3) Constant, for Two Different Formulations of the A Priori Cost Specifications

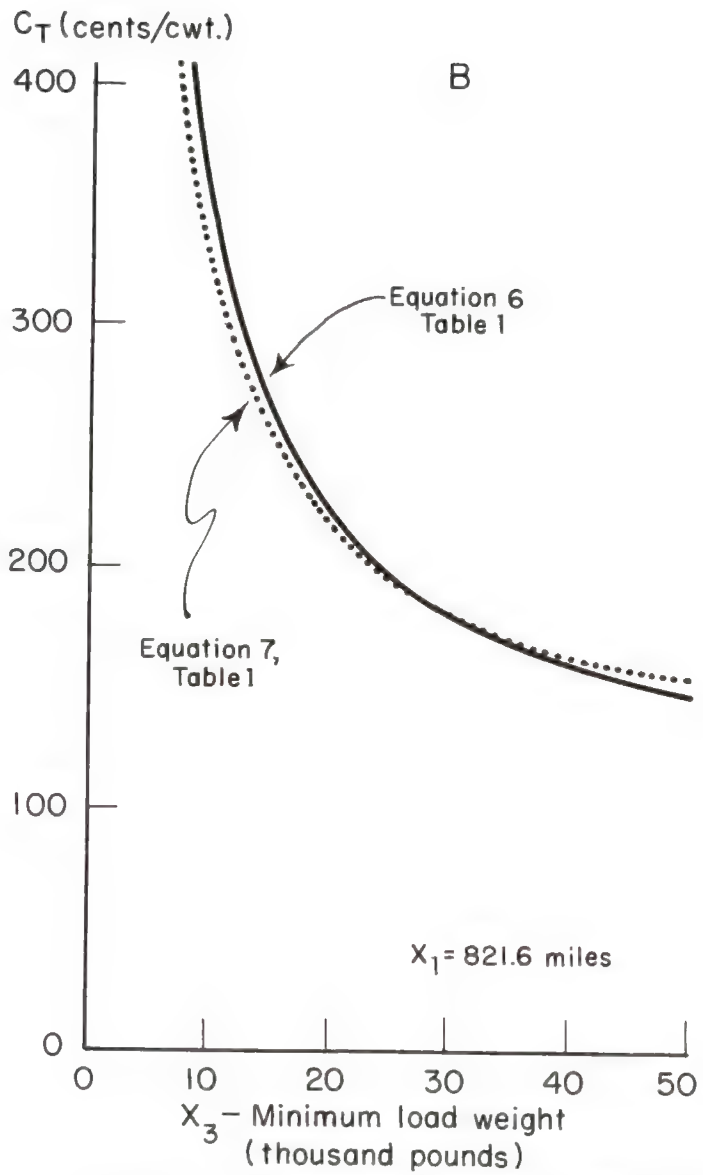

FIGURE 4B. Equations Derived from Motor Carrier Data Showing the Relationship of Charges (Cents Per Hundredweight) to Minimum Load Weight (X_3), Holding Distance (X_1) Constant, for Two Different Formulations of the A Priori Cost Specifications

this relation will be affected.[1/] The statistical significance of the coefficients of equation 7 failed to lead to a rejection of this formulation as a maintained hypothesis based on a priori reasoning. Therefore, it is believed that biased coefficients may have resulted from the formulations which exclude the weight variable. However, one may still choose one of the other formulations for various practical reasons--for instance, for the simplicity of other relations in estimating charges on the basis that the bias, if it exists, is unimportant, etc.

In summary then, considering both weight and distance, it appears that equations 2, 5, and 7 are the alternative formulations that might be selected

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[1/] Suppose we have a true specification of the form:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3. \qquad \text{(a)}$$

Under the general least-squares assumptions, it can be shown that an unbiased estimator of the coefficient b_1 can be obtained even though one or both of the variables X_2 and X_3 are excluded in some erroneous specification that is used, provided only that X_1 is uncorrelated with either of the other two variables. The estimator of the intercept (a) will still contain a specification bias. If the variable X_1 is correlated with one of the other variables, say X_3, the estimator of b_1 will be biased if X_3 is excluded from the specification used to estimate b_1. For proof of these statements, see H. Theil, Economic Forecasts and Policy (Amsterdam: North Holland Publishing Company, 1961), pp. 212-215 and 326-327.

Equation 7 of Table 1 is of a similar form; that is:

$$C_T = a + b_1X_1 + b_2\left(\frac{1}{X_3}\right). \qquad \text{(b)}$$

Now, equation 30 of Table 1 furnishes strong evidence that the variables X_1 and X_3 are uncorrelated. Therefore, if equation 7--or, for that matter, 3--is a correct specification in terms of the relevant explanatory variables, then one may exclude X_3 and still obtain an unbiased estimator of the coefficient b_1 (but not a). But, if the correct specification is of the form of equation 8; that is:

$$C_T = a + b_1X_1 + b_2\left(\frac{1}{X_3}\right) + b_3\left(\frac{X_1}{X_3}\right) \qquad \text{(c)}$$

or a similar form, it follows that X_1 must be correlated with the variable $\left(\frac{X_1}{X_3}\right)$ because X_1 is contained within it. Thus, exclusion of the weight variable will result in specification bias of the coefficient b_1.

for estimation of motor carrier transfer charges for frozen vegetables. The choice depends upon the weight one gives to the statistical criterion, economic considerations and a priori specification, and the practical considerations.

Direction of Travel.--As previously indicated, the data were divided into three subclassifications by direction of shipment; namely, W-E (west to east), E-W (east to west), and Other (all directions other than E-W and W-E). Equations containing four different formulations of weight and distance were fitted to the data in each of these groups, the results of which appear as equations 8 through 19 in Table 1. Several functional forms were used, not so much for analyzing the direction of travel but rather for their usefulness in analyzing the equations 1 through 7 in Table 1. Consequently, the discussion will be limited to the linear equations 8, 12, and 16 which are presented graphically in Figures 5A and 5B. It will be recalled that the main reason for looking at the direction of travel was to determine if any hypotheses were suggested. A common assertion is that charges are generally higher for one direction than another. This is supposed to put shippers of a particular area at a competitive disadvantage.

From Figures 5A and 5B, it is evident that the equations differ both in the distance and weight dimensions, depending upon the direction of travel considered; that is, the intercepts and the slopes differ for both the weight and distance dimensions. Actually, if one had established the hypothesis of equal slopes with respect to distance, a priori, the hypothesis would have been rejected at the .01 level for a comparison of either W-E or E-W with Other but would not have been rejected for a comparison of W-E with E-W. With respect to distance, these equations indicate that charges per hundredweight for W-E are higher for shorter distances and lower for longer distances than for E-W. However, a comparison of Other with both E-W and W-E indicates that charges for the Other direction are lower for shorter distance ranges and higher in longer distance ranges.

With respect to weight, the situation seems to be similar. That is, charges do not appear to be generally higher for one direction than for any other because charges depend on the weight transported as indicated in Figure 5B. These equations indicate that charges decrease more with increases in weight for the W-E direction than for either the E-W or Other direction equations, which suggests that weight considerations may be relatively more important for W-E shipments.

FIGURE 5A. Linear Equations Derived from Motor Carrier Data Showing Variation in the Relationship of Charges (Cents Per Hundredweight) to Distance (X_1), Holding Minimum Load Weight (X_3) Constant, for Different Directions of Shipment

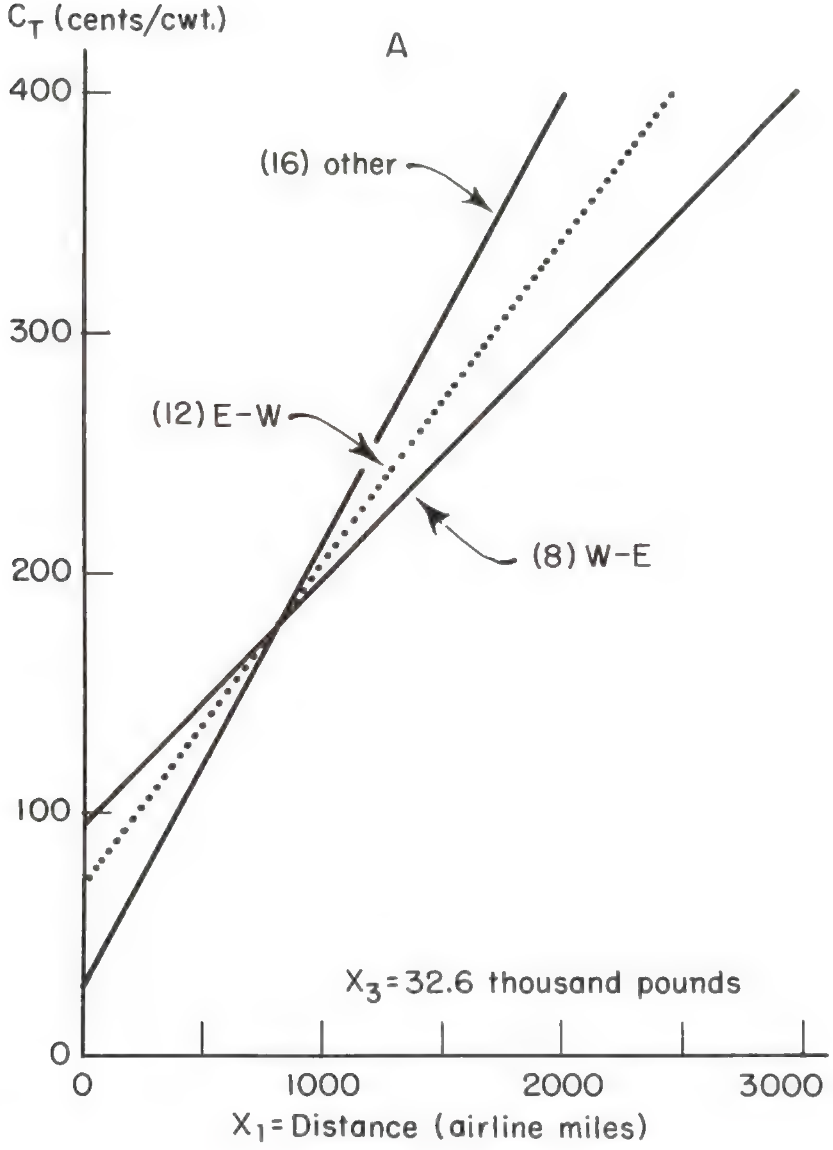
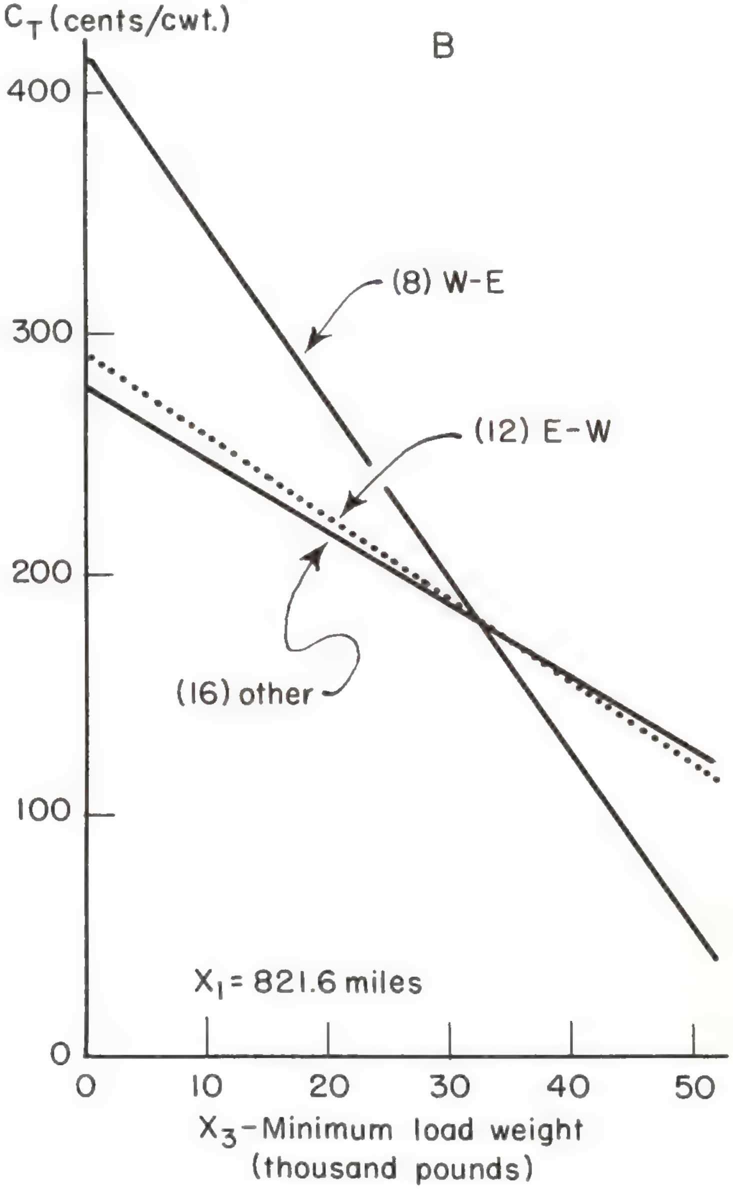


FIGURE 5B. Linear Equations Derived from Motor Carrier Data Showing Variation in the Relationship of Charges (Cents Per Hundredweight) to Minimum Load Weight (X_3), Holding Distance (X_1) Constant, for Different Directions of Shipment



If charges vary with weight and distance and by direction of travel according to the equations of Figures 5A and 5B, presumably there is some value of weight and distance for which the charges are equal. A simultaneous solution of these equations shows charges per hundredweight to be equal for all directions of travel at approximately 821.6 air miles and 32.6 thousand pounds minimum load weight. For convenience in comparing various equations, these values have been used repeatedly in the graphs of equations for motor carrier transfer charges.

In summary, there appear to be at least two hypotheses with respect to each of the variables, weight and distance, that are suggested by the data. The first concerns the level of charges with respect to each of the variables, and the second concerns the variation in charges as the given variable changes. That is, if the level of charges with respect to weight and/or distance is different and slopes are equal, then one can conclude that charges are higher for one direction of travel than another, regardless of distance traveled or weight transported. But if the slopes of the functions are different (with respect to either variable) between different directions of travel, such simple conclusions are not valid.

Rail Carrier Results

The results of the analyses of the two samples of rail data are presented separately in Table 2 and Table 3.[1] Each equation is designated by a small case letter. Equations of Table 3 which have a prime (') following the letter designation correspond--that is, are identical in form--to the equation in Table 2 with the same letter.

Initially, the same approach used in analyzing the motor carrier data was used for the rail data. That is, functions of essentially the same form as the ones first applied to the truck data were fitted to the total observations in each sample and, to the extent permitted by the data, to certain subclassifications by weight categories. However, the results of this initial effort indicated an inconsistency between Sample A and Sample B data with respect to the weight variable which could not be readily explained. As described later, further investigation led to the conclusion that the inconsistency was a result of the nature of the data obtained and that the data were inadequate for making

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[1] Sample A (Table 2) data include refrigeration charges; Sample B (Table 3) data consist of basic freight rates, excluding refrigeration charges. *Infra*, pp. 40 and 43.

TABLE 2

Transfer Charge Functions Derived from Rail Carrier Data for Frozen Vegetables Including Refrigeration Charges (Sample A)

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients[b]		t-ratios[b]	
				Air distance	Weight	Air distance	Weight
Overall equations							
a. $C_R = f(X_1, X_3)$	344	0.588	102.485	0.032	0.967	13.787	5.606[c]
b. $C_R = f(X_1, \log X_3)$	344	0.580	- 5.577	0.033	92.107	14.264	4.894[c]
c. $C_R = f(\log X_1, \log X_3)$	344	0.702	- 217.741	108.485	47.652	20.668	2.955[c]
d. $C_R = f(X_1, X_1^2, X_3)$	344	0.679	77.526	0.113 $- 0.258(10^{-4})$	0.447	13.254 - 9.832	2.770[c]
e. $C_R = f(X_1, X_3, X_3^2)$	344	0.771	1,030.635	0.0223	-39.500 0.422	12.684	-16.069 16.485
f. $C_R = f(X_1, X_1^2, X_3, X_3^2)$	344	0.817	909.656	0.083 $- 0.188(10^{-4})$	-35.397 0.375	12.376 - 9.257	-15.776 16.000
g. $C_R = f(X_1, X_1^2, \log X_3)$	344	0.676	36.373	0.116 $- 0.263(10^{-4})$	36.447	13.622 -10.067	2.090[c]
Weight categories							
h. $C_R = f(X_1)$ 36M	50	0.534	123.384	0.065		7.421	
i. $C_R = f(\log X_1)$ 36M	50	0.610	- 113.106	100.662		8.667	

(Continued on next page.)

TABLE 2--continued.

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients[b]		t-ratios[b]	
				Air distance	Weight	Air distance	Weight
j. $C_R = f(X_1, X_1^2)$ 36M	50	0.589	89.629	0.166 - 0.648(10^{-4})		4.029 - 2.511[d]	
k. $C_R = f(X_1)$ 50M	26	0.928	44.478	0.110		17.647	
l. $C_R = f(\log X_1)$ 50M	26	0.908	-234.241	128.926		15.404	
m. $C_R = f(X_1, X_1^2)$ 50M	26	0.953	23.719	0.190 - 0.583(10^{-4})		8.089 - 3.486	
n. $C_R = f(X_1)$ 60M	266	0.367	189.695	0.017		12.359	
o. $C_R = f(\log X_1)$ 60M	266	0.343	38.429	56.043		11.753	
p. $C_R = f(X_1, X_1^2)$ 60M	266	0.367	190.359	0.016 0.255(10^{-6})		1.951[d] 0.109[c]	
Direction of travel							
q. $C_R = f(X_1)$ 60M W-E	147	0.473	183.362	0.017		11.406	
r. $C_R = f(\log X_1)$ 60M W-E	147	0.408	31.115	56.618		10.002	
s. $C_R = f(X_1, X_1^2)$ 60M W-E	147	0.500	203.390	- 0.009 0.732(10^{-5})		- 0.927[c] 2.801	
t. $C_R = f(X_1)$ 60M E-W	110	0.518	190.976	0.021		10.768	

Continued on next page.)

TABLE 2--continued.

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients[b]		t-ratios[b]	
				Air distance	Weight	Air distance	Weight
u. $C_R = f(\log X_1)$ 60M E-W	110	0.497	5.936	68.525		10.321	
v. $C_R = f(X_1, X_1^2)$ 60M E-W	110	0.519	185.843	0.027 - 0.204(10^{-5})		2.476 - 0.623[c]	

[a] C_R = charges in cents per hundredweight.

X_1 = airline distance, miles.

X_3 = minimum load weight, thousand pounds.

log = logarithm to the base 10.

M = thousand pounds.

W-E = west to east, and E-W = east to west.

[b] Where two figures appear for a given equation, the upper figure corresponds to the coefficient of the first term for the variable, and the lower figure corresponds to the coefficient of the second term. For example, equation d has two distance variables, X_1 and X_1^2, and the regression coefficients are 0.113 and -0.258(10^{-4}), respectively.

[c] Not significant at the .05 level.

[d] The coefficient was significant at the .05 level but not at the .01 level.

TABLE 3

Transfer Charge Functions Derived from Rail Carrier Data for Frozen Vegetables Excluding Refrigeration Charges (Sample B)

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients[b]		t-ratios[b]	
				Air distance	Weight	Air distance	Weight
Overall equations							
a'. $C_R = f(X_1, X_3)$	161	0.773	153.062	0.118	- 2.109	23.186	-10.932
b'. $C_R = f(X_1, \log X_3)$	161	0.786	448.776	0.120	- 239.071	24.116	-11.702
c'. $C_R = f(\log X_1, \log X_3)$	161	0.798	- 27.861	165.460	- 173.168	24.999	- 9.374
d'. $C_R = f(X_1, X_1^2, X_3)$	161	0.816	108.908	0.213 - 0.590(10^{-4})	- 1.756	13.099 - 6.050	- 9.551
e'. $C_R = f(X_1, X_3, X_3^2)$	161	0.814	366.757	0.122	- 11.480 0.095	26.005	- 7.118 5.845
f. $C_R = f(X_1, \frac{1}{X_3})$	161	0.792	- 55.248	0.120	4,758.337	24.495	12.010
ff. $C_R = f(X_1, \frac{1}{X_3}, \frac{X_1}{X_3})$	161	0.796	5.442	0.066	2,437.133 2.122[d]	2.321[c]	1.933[c] 1.937[c][e]
g'. $C_R = f(X_1, X_1^2, \log X_3)$	161	0.826	359.420	0.211 - 0.570(10^{-4})	- 201.164	13.351 - 6.011	-10.303
Weight categories							
h'. $C_R = f(X_1)$ 36M	113	0.951	61.885	0.147		46.220	
i'. $C_R = f(\log X_1)$ 36M	113	0.889	-304.261	167.600		29.749	
j'. $C_R = f(X_1, X_1^2)$ 36M	113	0.954	52.367	0.182 - 0.268(10^{-4})		13.675 - 2.736	

(Continued on next page.)

TABLE 3--continued.

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients[b]		t-ratios[b]	
				Air distance	Weight	Air distance	Weight
k'. $C_R = f(X_1)$ 50M	15	0.910	32.398	0.094		11.472	
l'. $C_R = f(\log X_1)$ 50M	15	0.908	-234.241	128.926		15.404	
m'. $C_R = f(X_1, X_1^2)$ 50M	15	0.994	- 13.784	0.272 $- 0.012(10^{-7})$		19.553 -12.965	
n. $C_R = f(X_1)$ 60-70M	19	0.613	125.774	0.043		5.187	
o. $C_R = f(\log X_1)$ 60-70M	19	0.631	-172.670	114.287		5.391	
p. $C_R = f(X_1, X_1^2)$ 60-70M	19	0.629	97.252	0.093 $- 0.208(10^{-4})$		1.548[f] - 0.842[f]	
Direction of travel							
q. $C_R = f(X_1)$ 36M W-E	49	0.958	68.881	0.139		32.804	
r. $C_R = f(\log X_1)$ 36M W-E	49	0.945	-405.248	203.002		28.369	
s. $C_R = f(X_1, X_1^2)$ 36M W-E	49	0.970	42.539	0.217 $- 0.526(10^{-4})$		11.800 - 4.325	
t. $C_R = f(X_1)$ 36M E-W	22	0.919	56.273	0.158		15.053	
u. $C_R = f(\log X_1)$ 36M E-W	22	0.849	-330.226	178.264		10.611	
v. $C_R = f(X_1, X_1^2)$ 36M E-W	22	0.920	50.911	0.179 $- 0.156(10^{-4})$		3.701 - 0.437[f]	
x. $C_R = f(X_1)$ 36M Other	42	0.966	63.065	0.140		33.646	

(Continued on next page.)

TABLE 3--continued.

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients[b]		t-ratios[b]	
				Air distance	Weight	Air distance	Weight
y. $C_R = f(\log X_1)$ 36M Other	42	0.891	-249.253	146.144		18.066	
z. $C_R = f(X_1, X_1^2)$ 36M Other	42	0.968	57.470	0.163 $- 0.185(10^{-4})$		10.082 - 1.477[f]	

[a] C_R = rail rate, cents per hundred pounds.

X_1 = airline distance, miles.

X_3 = minimum load weight, thousand pounds.

Log = logarithm to the base 10.

M = thousand pounds.

W-E = west to east; E-W = east to west; and Other = all directions other than E-W and W-E.

[b] Where two figures appear for a given equation, the upper figure corresponds to the coefficient of the first term for the variable and the lower figure corresponds to the coefficient of the second term. For example, equation d' has two distance variables, X_1 and X_1^2, and the regression coefficients are 0.213 and $-0.590(10^{-4})$, respectively.

[c] The coefficient was significant at the .05 level but not at the .01 level.

[d] Coefficient of the variable $(\frac{X_1}{X_3})$.

[e] t-ratio of the coefficient of the variable $(\frac{X_1}{X_3})$.

[f] Not significant at the .05 level or above.

valid statistical tests of the hypotheses with respect to weight that were suggested by the a priori specifications. In view of this and the earlier discussion of specification bias, it is believed that statistical results concerning the distance variable might also be affected. Consequently, subsequent effort was directed toward obtaining an equation which most accurately described rail transfer charges for the data and which could be used for estimation of rail transfer charges for frozen vegetables. With this in mind, we will briefly discuss the results, considering first the relationship of charges to weight; second, the relationship of charges to distance; and third, the different directions of travel.

Relationship of Charges to Weight.--A linear relationship of charges to weight and a linear relationship of charges to the logarithm of weight were fitted to each sample of data (A and B) in five different equations (a, b, c, d, and g). For all of these equations, the coefficient of weight had a negative sign for Sample B and a positive sign for Sample A, and the coefficient of weight was significantly less than zero (at the .01 level) for every case in Sample B but was significantly less than zero for no case in Sample A. This apparent inconsistency was at first quite puzzling. The results of Sample B data, which consist of only the basic freight rates, appear to support the a priori specifications; while the results from Sample A data, which consist of the basic freight rate plus refrigeration charges, appear to contradict these specifications.

One might first suspect that the apparent difference between the two sets of data--the refrigeration charges--would account for this inconsistency, but this is not the case.[1] A look at the breakdown of results by weight categories, however, indicates the most probable reason for the inconsistent results. Comparison of the number of observations in each weight category shows considerable concentration of observations in the weight category of 60,000 pounds for Sample A and a similar concentration in the weight group of 36,000 pounds for Sample B. Consequently, the coefficient of any simple function of weight--that is, one which contains only one term for the weight variable--is largely determined by this concentration of observations, which has a disproportionate weight relative to observations in other weight categories. The intercepts of equations h, k, and n give some indication that the average level of charges at 36,000 pounds is generally higher than that for 50,000 pounds but lower than that for 60,000 pounds.[1/] To adequately describe the data, then, the function should first decrease and then increase. Since the simple functions employed do not possess this property, the large concentration of observations causes such equations to have a positive weight coefficient in Sample A and a negative coefficient in Sample B. Equations e and f of Table 2 and equation e' of Table 3, shown graphically in Figures 6A and 6B, confirm the above reasoning. With respect to weight alone (Figure 6B), equations e, f, and e' seem to describe the data more accurately than other formulations, as indicated by the higher R^2 values in both Sample A and Sample B; that is, compare equations a and b with e in Table 2, and compare a' and b' with e' in Table 3.

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[1] Holding distance constant and assuming that the only difference between the two equations a and a' is the refrigeration charge, subtraction of a' from a should yield a relationship for refrigeration charges. Among other things, the derived relationship shows that refrigeration charges per unit of weight increase as weight increases. But this is inconsistent with known facts. That is, frozen vegetables are shipped in mechanically refrigerated cars for which charges are quoted on a per car basis, causing charges per unit of weight to decrease with increases in weight.

In view of the above reasoning and the remarks at the beginning of the discussion of rail transfer charge results, equations incorporating the a priori specifications of the relations of the form (6) and (10) could not be expected to give meaningful results from these data, particularly Sample A.[2/] Relationships of this form (equations f and ff, Table 3) were obtained from Sample B data; and, although the results were consistent with the a priori specifications, the coefficients of equation ff were not significant at the .01 level.

For use in estimating transfer charges, equation e presents the problem of selecting the appropriate weight because the function has a minimum at some weight. The minimum for equation e of Table 2 occurs at approximately 46,800 pounds, while the minimum for equation e' of Table 3 occurs at approximately 60,600 pounds. Because the minimum of e occurs in a range of relatively few observations--that is, 50,000 pounds--and because most of the observations are

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[1/] It is recognized that this is not conclusive evidence since the slope coefficients differ for each equation and the low R^2 for some equations suggests a large variance for the intercept, but observation of the data and the lack of evidence to the contrary offer some support for this statement. (The arithmetic mean charges--cents per hundredweight--for equations h, k, and n of Table 2 were approximately 177, 130, and 260, respectively. For the weight categories of 36,000, 50,000, and 60,000 pounds in Sample B, the arithmetic mean charges were approximately 153, 118, and 190, respectively.)

[2/] *Supra*, pp. 21 and 22.

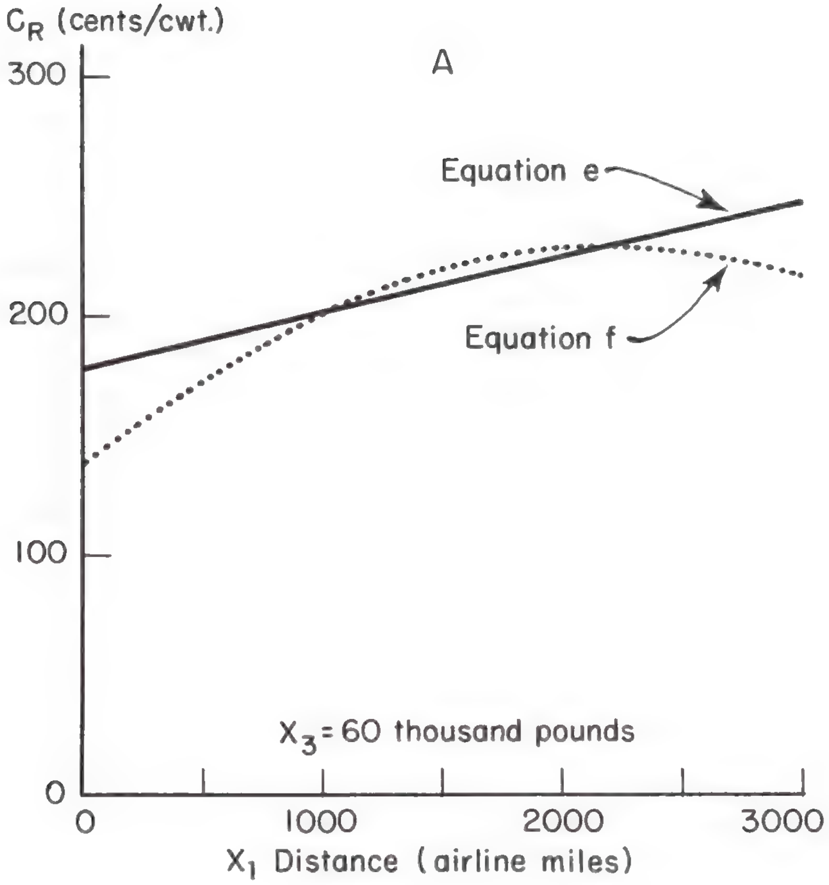

FIGURE 6A. Rail Transfer Charge Equations e and f of Table 2 Showing Charges (Cents Per Hundredweight) as a Function of Distance (X_1), Holding Minimum Load Weight (X_3) Constant

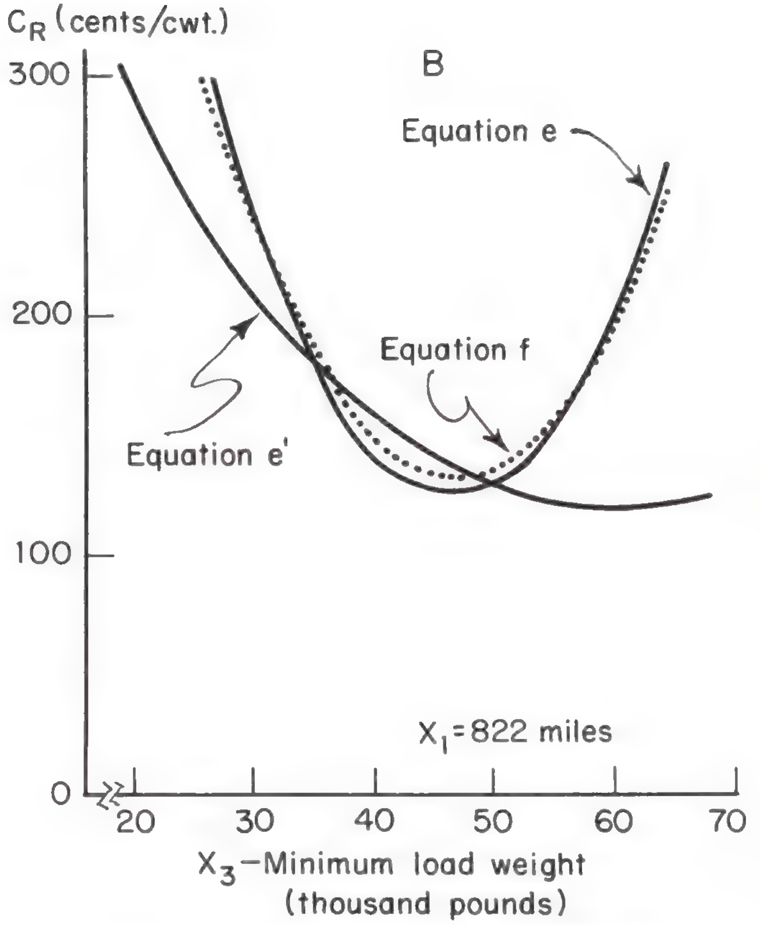

FIGURE 6B. Rail Transfer Charge Equations e and f of Table 2 and e' of Table 3 Showing Charges (Cents Per Hundredweight) as a Function of Minimum Load Weight (X_3), Holding Distance (X_1) Constant

for 60,000 pounds, the latter weight was selected as the most appropriate minimum load weight for use in estimating charges for frozen vegetables.

Relationship of Charges to Distance.--With respect to the form of equations, the results of the relationship of charges to distance for both samples followed the same general pattern as those for motor carrier data. Four exceptions occurred. First, several equations which were quadratic in distance had nonsignificant coefficients for both terms of the equation. Second, one quadratic equation (s, Table 2) had a nonsignificant negative coefficient for the distance variable. Third, one quadratic equation had a negative intercept, m'. Fourth, for reasons stated earlier, only limited use of the a priori specifications was made in Sample B.1/

For the equations derived from the total number of observations for each sample, we have the following comparative statistical results: For Table 2, the adjusted R^2 was greater for the log form than for the quadratic form which, in turn, was greater than for the linear form. This is evident in the comparisons (c, g), (d, a), and (c, b), respectively. For Table 3, the following indicated comparisons of the different equation forms in the order of decreasing adjusted R^2 were the quadratic forms (g', c') and (d', a'), the log form (c', b'), and the linear form.

Summarizing the comparative statistical results for the subclassifications by direction of travel and weight categories, we have the following: In Table 2, comparing the R^2 (or $\bar{R}^2$, whichever is appropriate) values shows the R^2 for the linear equations to be greater than for the log form in four cases (k, l), (o, n), (q, r), and (t, u) and less in one case (i, h). R^2 for the quadratic form is greater than for the linear form in three comparisons (j, h), (m, k), and (s, q) and smaller in two (n, p) and (t, v). The log form had a higher R^2 than the quadratic form in one case (l, j). For Table 3, the comparison of R^2 values shows a similar pattern. R^2 for the linear equations is greater than for the log form in five comparisons (h', j'), (k', l'), (q, r), (t, u), and (x, y) and smaller for one (o, n). The quadratic form had a higher R^2 than the linear form in three cases (s, z), (t, v), and (n, p). R^2 for the log form was greater than for the quadratic form in one comparison (o, p). Considering the quadratic form for these subclassifications, the hypothesis that the coefficient of distance squared was significantly different from zero at

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1/ See Figure 4A, p. 35.

the .01 level was rejected for three equations of Table 3 (p, v, and z) and was not rejected for three equations (j', m', and s). For Table 2, the hypothesis was rejected for three equations (j, p, and v) and was not rejected for one equation, m. In many of these equations, as indicated in the tables, the hypothesis would have been rejected at the .05 level. Moreover, in several of these equations, the coefficient of distance per se was not significant at the .01 level. The only other equation form in which the coefficient of distance was not significant at the .01 level was equation ff in which the coefficient was significant at the .05 level.

Regarding economic considerations, three factors are worth mentioning: (1) the negative intercepts, (2) a negative coefficient of distance, and (3) the relationships of charges to distance which decrease within the range of the data or within the range for which estimated charges are required. Negative intercepts were obtained for equations containing the log transformation of distance in three (c, i, and l) of the six equations in Table 2 and in all seven of such equations in Table 3. One equation, m', of Table 3, which is a quadratic in distance, had a negative intercept. Also, equation b of Table 2, which is linear in distance, had a negative intercept. The latter occurrence, however, seemed to result from the log transformation of weight as indicated by comparing equations b and a. The negative coefficient of distance was obtained in equation s of Table 2, which is a quadratic in distance, and the second coefficient of this equation was positive. Several of the equations which are quadratic in distance possess maximum values and a decreasing segment, either within the range of the sample data or within the range for which estimated charges are required. Consequently, these equations, while possibly having higher R^2 values, are inadequate for estimating transfer charges in an interregional study unless one argues that charges which decrease with increasing distance are appropriate.

In selecting a relationship for estimation of charges, as indicated earlier, the choice is limited to the equations of Table 2. In view of the earlier remarks about obtaining the most accurate description of the data for transfer charge estimation, the choice is further limited to equations e and f which have the highest R^2 values. These equations are presented in Figure 6A for illustrative purposes. As the figure indicates, a maximum point occurs at approximately 2,218 air miles for equation f, and past this point the function decreases. Many of the distances for which estimated charges are required are greater than 2,300 miles. Consequently, equation e is selected for use in estimation of charges.

In summary of the relationship of rail charges to distance, the above results seem to be consistent with and support those derived from the truck data. Although the linear relationship did not have the highest R^2 values and thus did not fit the data as well in a statistical sense, an evaluation in terms of the economic and practical considerations as well as the statistical criterion reveals that this relationship gives consistent results throughout. On the other hand, the quadratic relationship and the log transformation of distance, in addition to producing inconsistent results, were found to be inadequate on both statistical and economic grounds for the former and on economic and practical considerations for the latter. Thus, while the hypothesis of curvilinearity is not rejected per se, it is felt that the nonlinear relationships used in this study are incorrect specifications of the relationship between rail charges per hundredweight and distance.

Direction of Travel.--As a result of the adverse results with the weight variable, this variable was not entered explicitly in the equations. Because of the grouping of observations at the two extreme weights in each sample, only one weight category was used for each sample. For Sample A, the observations at 60,000 pounds were classified into two groups by direction of travel. Only E-W and W-E directions were considered due to the small number of observations in the Other category. For Sample B, the observations at 36,000 pounds were subdivided by direction of travel in the same three categories as for the truck data.

The linear equations t and q of Table 2 are shown graphically in Figure 7; and the linear equations q, t, and x of Table 3 are shown in Figure 8. Comparatively speaking, there is less variation in charges by direction of travel than for truck transportation. The equations in Figure 8 are quite close together, although they have a greater slope than those of Figure 7. The two equations of Figure 7 indicate that the E-W direction has a higher level of charges than W-E at all distances. In summary, since the slopes of comparable equations differ very little, these results appear to suggest only one hypothesis, if any, and that is the hypothesis of equal intercepts. Rejection of this hypothesis for the case shown in Figure 7 would imply that charges were generally higher for E-W shipments than for W-E shipments. However, it must be remembered that this conclusion is conditional; it depends on the load weight considered. As demonstrated with motor carrier data, the level and slope of the relationship of charges to distance may change as the minimum load weight changes.

FIGURE 7. Equations t and q of Table 2 Showing Variation in Estimated Transfer Charge Equations for Different Directions of Shipment

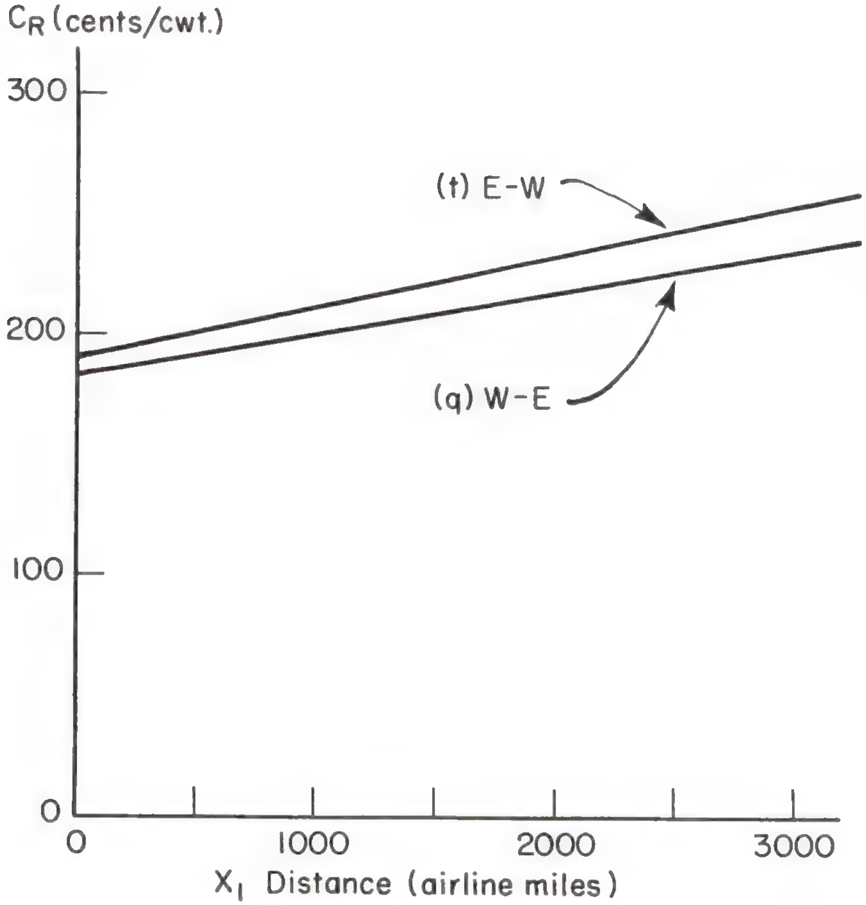
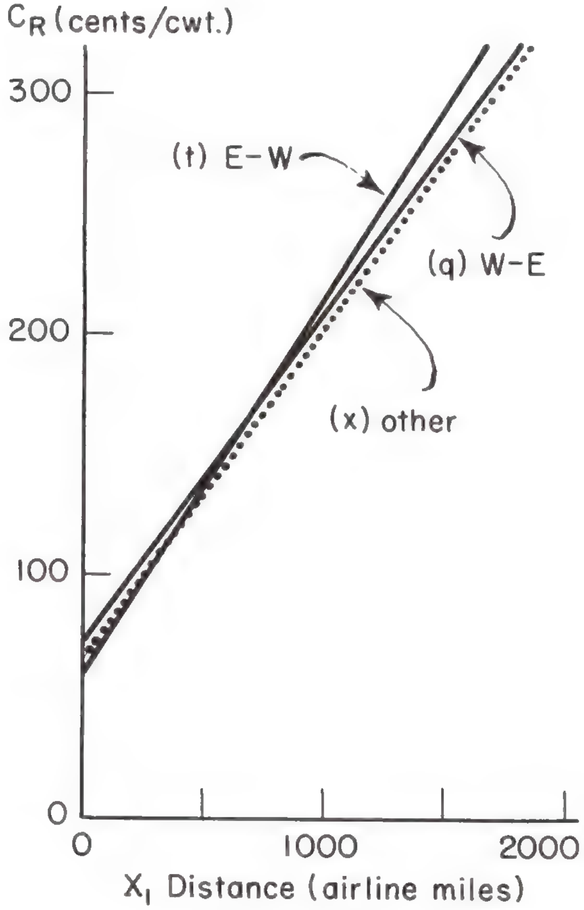


FIGURE 8. Equations t, q, and x of Table 3 Showing Variation in Estimated Freight Rate Equations for Different Directions of Shipment



Derivation of Combined Transfer Charge Functions

Where alternative modes of transport such as rail and truck exist, the usual approach in interregional studies is to choose the alternative representing the lowest charge for any given distance as represented by functional relationships derived from sample data on quoted charges for each mode of transport. Presumably, the rationale for this procedure is that the least-cost alternative, *ceteris paribus*, is the economically rational choice. Thus, in the procedure there is the implicit assumption that the functional relationships used either incorporate all of the economic factors relevant to the decision between alternative modes of transport or hold constant those which are not represented.

The procedure is illustrated in Figure 9 where equation 2 of Table 1 and equation e of Table 2 have been presented for minimum load weights of 33,000 and 60,000 pounds, respectively. Charges are equal at approximately 1,096 air miles where the two equations intersect. For distances less than or equal to 1,096 air miles, the charges for truck transport represented by C_T would be used; and for distances greater than 1,096 air miles, the charges for rail transport represented by C_R would be used. But data on shipments of frozen fruits and vegetables exist which raise some doubt about the accuracy of this procedure.[1] Part of these data is presented in Table 4 in which the percent shipped by rail and the percent shipped by truck have been computed for each mileage block. The data were obtained from 73 processors. The total amounts shipped in each year accounted for approximately 37 and 38 percent of the total production of frozen fruits and vegetables for the years 1955 and 1957, respectively.[2]

In our illustration, 1,096 air miles is approximately equal to 1,368 highway miles; and, as can be seen from Table 4, substantial shipments occur below this distance for rail and above this distance for truck. For example, in the mileage block of 751-1,001 miles, 17-26 percent of the shipments are by rail; and for the mileage block of 1,501-2,000 miles, 50-60 percent of the shipments are by truck. The question is immediately raised regarding the reason for this discrepancy between the estimated relationships and the data of Table 4.

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[1] U. S. Agricultural Marketing Service, *Interstate Trucking of Frozen Fruits . . .*, p. 18.

[2] Computed from figures given in *ibid*.; also, Table 4.

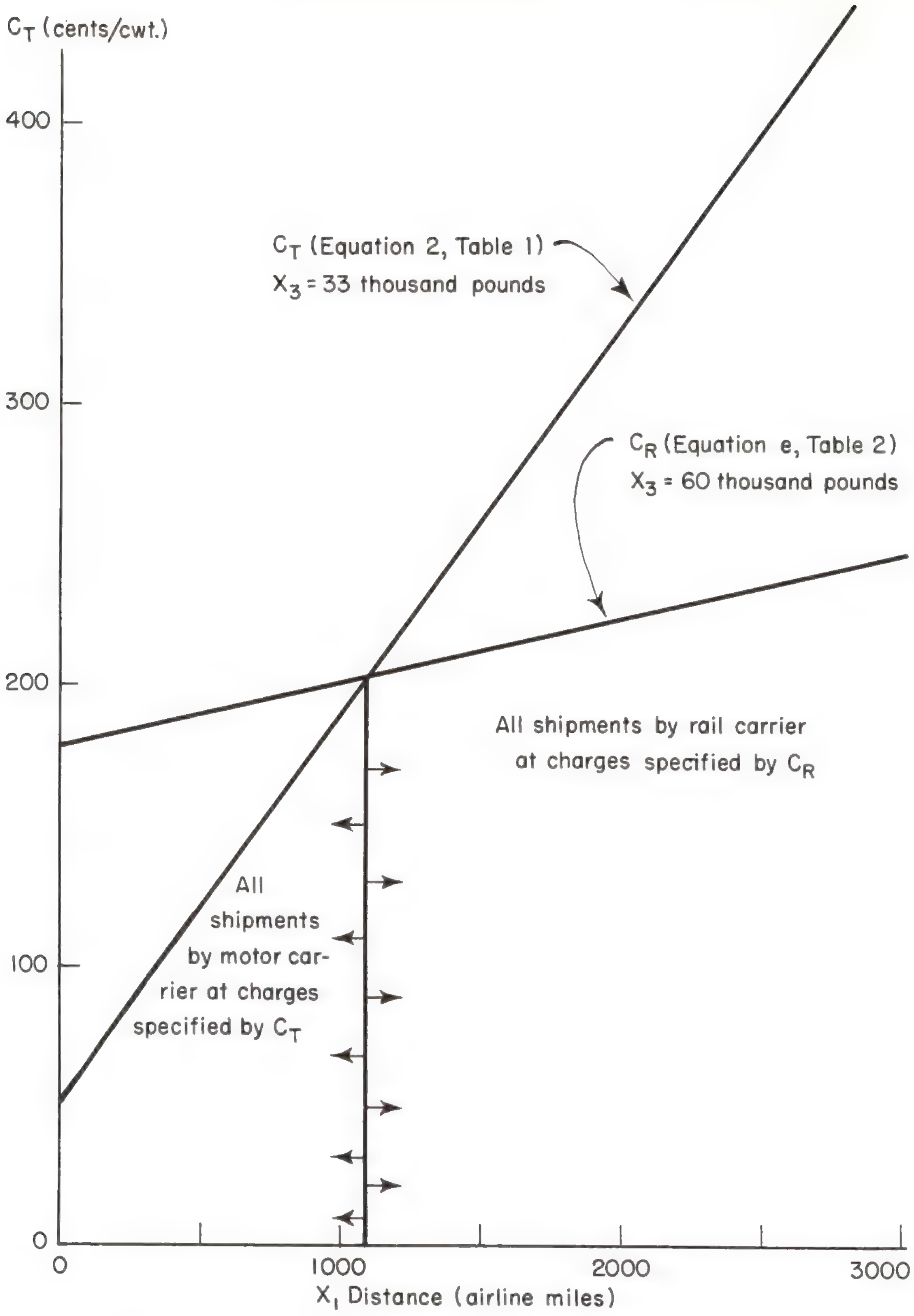

FIGURE 9. Representation of the Usual Procedure for Designating Rail and Truck Shipments and Corresponding Charges from Estimated Transfer Charge-Distance Relationships for Truck (C_T) and Rail (C_R), Holding Minimum Load Weight (X_3) Constant at a Specified Level

TABLE 4

Data Showing the Quantity and Percent of Frozen Vegetables Shipped and the Quantity and Percent Shipped by Truck and Rail, by Mileage Blocks, 1955 and 1957

Mileage block	1955						1957					
	Total shipments		Shipments by rail		Shipments by truck		Total shipments		Shipments by rail		Shipments by truck	
	thousand pounds	percent	thousand pounds	percent[a]	thousand pounds	percent[a]	thousand pounds	percent	thousand pounds	percent[a]	thousand pounds	percent[a]
1- 250	127,413	19.1	5,206	4.1	122,207	95.9	190,930	24.6	2,453	1.3	188,477	98.7
251- 500	84,607	12.7	3,074	3.6	81,533	96.4	104,070	13.4	5,224	5.0	98,846	95.0
501- 750	47,711	7.1	4,135	8.7	43,576	91.3	42,270	5.5	278	.7	41,992	99.3
751-1,000	71,136	10.7	12,180	17.1	58,956	82.9	54,428	7.0	14,570	26.8	39,858	73.2
1,001-1,500	51,638	7.7	14,858	28.8	36,780	71.2	58,734	7.6	18,931	32.2	39,803	67.8
1,501-2,000	37,965	5.7	17,914	47.2	20,051	52.8	51,382	6.6	20,108	39.1	31,274	60.9
2,001-2,500	89,905	13.5	75,133	83.6	14,772	16.4	102,645	13.2	76,623	74.6	26,022	25.4
2,501-3,000	89,300	13.4	85,037	95.2	4,263	4.8	100,346	12.9	96,742	96.4	3,604	3.6
3,001 and over	67,684	10.1	67,247	99.4	437	.6	71,362	9.2	69,732	97.7	1,630	2.3
Total	667,359	100.0	284,784		382,575		776,167	100.0	304,661		471,506	

a/ Percent shipped by rail (or truck) of the total amount shipped in the given mileage block. These percentages are computed from the quantity data given in the source below.

Source: U. S. Agricultural Marketing Service, Interstate Trucking of Frozen Fruits and Vegetables Under Agricultural Exemption, Market Research Report No. 316, 1959.

The justification that shippers are not economically rational is felt to be inadequate and unrealistic. Instead, it is presumed that the reason is to be found in the implicit assumption of the rationale for the procedure set out above. Usually, only distance is considered in deriving the functional relationships from quoted charges. The procedure in this study included one more variable--minimum load weight. But this still does not include or hold constant, in fact, other factors which may have economic relevance to the shipping decision. It was recognized earlier that speed, which is closely related to the time required for shipping, was not included. But the time required for shipment may be quite relevant and different between modes of transport. Moreover, there is evidence that stop-offs en route, storage in transit, loading and unloading cost to shippers, and risk, in addition to numerous other factors which differ between modes of transport, are relevant to shippers.[1/] Even if we assume that the derived equations are accurate representations of the quoted charges per hundredweight, it can be inferred from the above discussion that these relationships do not accurately represent what might be termed the "effective charges" from the industry point of view; that is, the quoted charges constitute effective charges from the industry viewpoint only to the extent they are used. For example, suppose that for a given distance and commodity we have a quoted rail charge of $1.00 per hundredweight and a truck charge of $2.00 per hundredweight, and suppose we know that for this given distance 1 million pounds of the commodity are shipped--50 percent going by rail and 50 percent by truck; then the effective charge per hundredweight from the industry viewpoint is $1.50 or, in other words, 50 percent of the rail charge plus 50 percent of the truck charge.[2/] For each individual shipment considered separately, the effective charge is equal to the quoted charge; but in the aggregate, this equality only occurs when all of the commodity is shipped by one or the other modes of transport for the given distance.

While it is not practically feasible to include the multitude of factors explicitly in the derivation of transfer charge functions, the data of Table 4

[1/] U. S. Agricultural Marketing Service, Interstate Trucking of Frozen Fruits . . ., pp. 30-36.

[2/] That is, assuming that the quoted charges are actually paid by the shippers and that no hidden charges or discounts are employed.

reflect the effects of many of the above factors. And the discrepancy between these data and the results of the outlined procedure is felt to be large enough to justify an attempt to incorporate this evidence. One suggested procedure was to combine the C_R and C_T relations, utilizing the mileage block data, and obtain a combined function of the following form:

$$\overline{C} = YC_R + (1 - Y)\, C_T$$

where

$\overline{C}$ = combined transfer charge per hundredweight.

Y = percent of shipments by rail as a function of distance.

C_R = derived rail transfer charge function.

C_T = derived truck transfer charge function.

This procedure necessitates obtaining Y as a function of distance from the data of Table 4. Using these data, the percent shipped by rail for each mileage block is computed and plotted at the midpoint of the mileage block in Figure 10A. In order to do this for the open-end mileage block of 3,001 miles and over, the end point of that interval was roughly estimated to be 3,500 miles. The data in Figure 10A roughly approximate an S-shaped curve. Intuitively, one might argue that the curve should reach the horizontal axis at very small distances and be asymptotic to the upper limit of 100 percent at large distances. This implies that for very small distances no rail transport would be used but that even for the maximum distance some truck transport would be used. Curves of this exact form are somewhat difficult to fit statistically; and, in addition, they are quite inconvenient to use because of the resulting complexity of the combined transfer charge relationship. The mileage block data of Table 4 were converted to air miles using equation 29 of Table 1. Then, as a first approximation, a cubic equation in distance was fitted to the data for 1955 and to the combined data for 1955-1957.1/ The equations are presented graphically in Figure 10B and appear in tabular form in Table 5 as equations (1) and (2). Table 5 summarizes the equations used in this section and the results of

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1/ An equation of the form $Y = a + b\left(\frac{1}{X}\right)$ was later tried but was discarded since deviations of the data from the fitted equation were substantial.

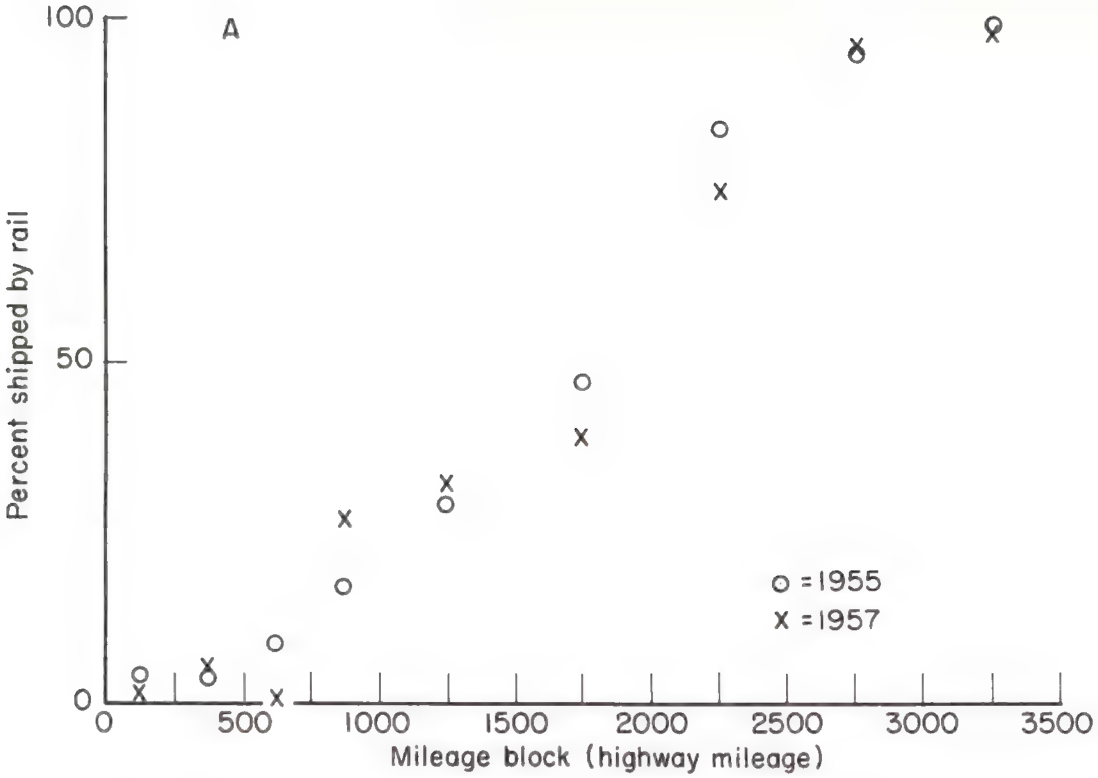

FIGURE 10A. Percent of Shipments by Rail, Plotted at the Midpoint of Each Mileage Block

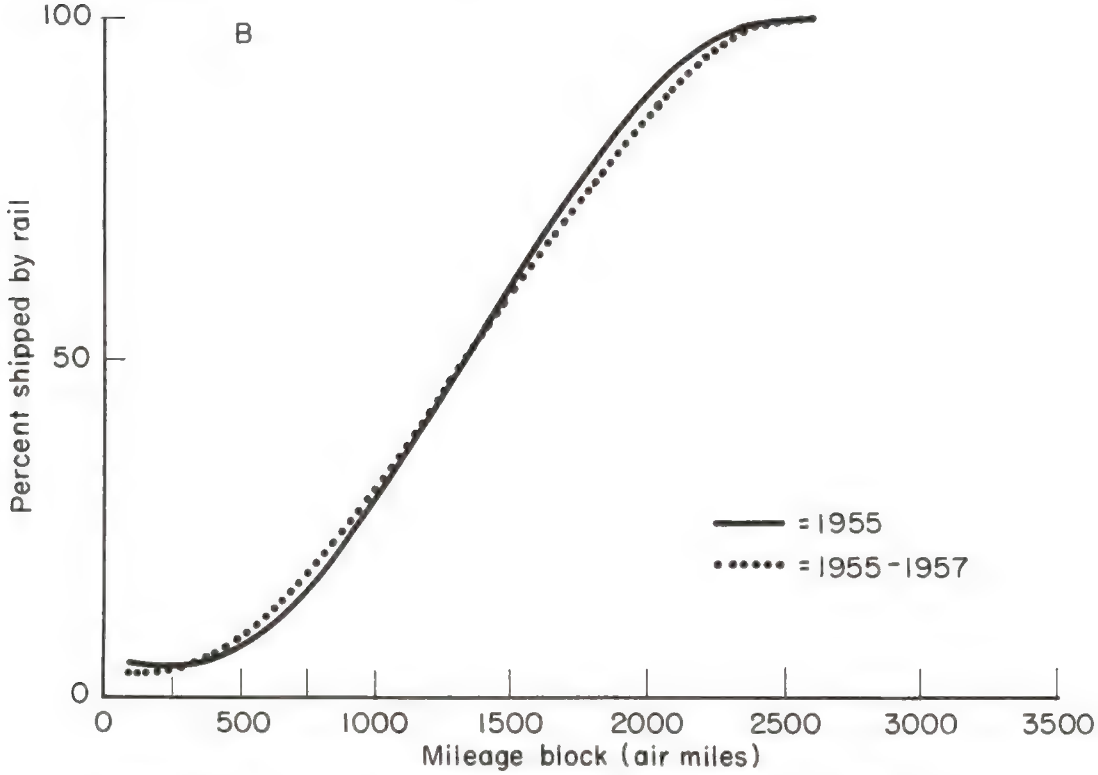

FIGURE 10B. Cubic Equations Showing the Percent of Shipments by Rail as a Function of Airline Distances for 1955 and Combined 1955-1957 Data

TABLE 5

Relationships Employed and Results Obtained in Deriving Various Combined Functions for Transfer Charges of Frozen Vegetables

Equation	R^2	Constant term	X_1	$X_1^2(10^{-6})$	$X_1^3(10^{-9})$	$X_1^4(10^{-12})$	$t(b_1)$	$t(b_2)$	$t(b_3)$
Percent shipped by rail (Y)									
Air miles									
(1) $Y = f(X_1, X_1^2, X_1^3)$ 1955	0.993	0.073	- 0.00029	0.678	- 0.016		-1.759	4.607	-4.568
(2) $Y = f(X_1, X_1^2, X_1^3)$ 1955-1957	0.980	0.047	- 0.00017	0.557	- 0.013		-1.035	3.683	-3.612
Truck (C_T) and rail (C_R)									
(3) $C_T = f(X_1)$		51.312	0.139						
(4) $C_T = f(X_1, X_1^2)$		21.856	0.216	- 0.038					
(5) $C_R = f(X_1)$		178.848	0.022						
(6) $C_R = f(X_1)$		190.848	0.022						
Combined functions ($\overline{C}$)									
(7) $\overline{C} = f(X_1, X_1^2, X_1^3, X_1^4)$		57.287	$110.971(10^{-3})$	91.777	-81.846	15.540			
(8) $\overline{C} = f(X_1, X_1^2, X_1^3, X_1^4)$		57.845	$108.836(10^{-3})$	98.458	-83.448	15.540			
(9a) $\overline{C} = f(X_1, X_1^2, X_1^3, X_1^4)$; $X_1 \leq 1660$		57.287	$110.971(10^{-3})$	91.777	-81.846	15.540			
(9b) $\overline{C} = f(X_1)$; $X_1 > 1660$		220.122	$22.823(10^{-3})$						

various attempts to derive a combined transfer charge relationship; and, unless otherwise stated, reference to equation numbers in this section will refer to Table 5 in order to avoid repetition.

Using equations (2), (3), and (5), the combined transfer charge function (7) was obtained. Equation (3) is obtained from equation 2 of Table 1 for a minimum load weight of 33,000 pounds, and equation (5) is obtained from equation e of Table 2 for a minimum load weight of 60,000 pounds. Equations (3), (5), and (7) are shown graphically in Figure 11 as C_T, C_R, and $\overline{C}$, respectively. As evident in the figure, the $\overline{C}$ equation reaches a maximum at approximately 1,900 miles and then decreases to the C_R equation, at which point the percent shipped by rail is 100. Past this point, the $\overline{C}$ equation increases at an increasing rate. This results from the use of the cubic equation (2) used as an approximation to the mileage block data. This part of the curve can be disregarded because once equation (2) reaches 100 percent, the relevant equation is C_R. Of greater concern is the decreasing segment of $\overline{C}$ between its maximum and the point at which it reaches C_R. In terms of estimation of transfer charges, this is unacceptable for the same reason given for the decreasing quadratic functions.[1]

Using equation (4)--which is derived from equation 5 of Table 1 for a minimum load weight of 33,000 pounds--and equations (5) and (2), a $\overline{C}$ function was obtained graphically as shown in Figure 12. The result was essentially the same as the first attempt. An equation was not obtained for this function because of the difficulty involved and the complexity of the result.[2]

An alternative procedure was suggested for combining equations (2), (3), and (5), the result of which is shown graphically in Figure 13 and as equations (9a) and (9b) in Table 5. This procedure extends $\overline{C}$ at the point where the slope of $\overline{C}$ and C_R are equal by an equation (9b), having the same slope as C_R. Admittedly, the rationale for such a procedure is somewhat less than conclusive. However, the following may be worth considering in this respect, assuming that equations (3) and (5) are adequate representations of quoted charges.

The data of Table 4 and the accompanying answers to questionnaires presented in the source of that data show that some shippers use rail transport in the lower distance ranges for various reasons, such as better refrigeration

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[1] Supra, p. 50.

[2] Points used to obtain the graphic representation were obtained through the use of a computer program.

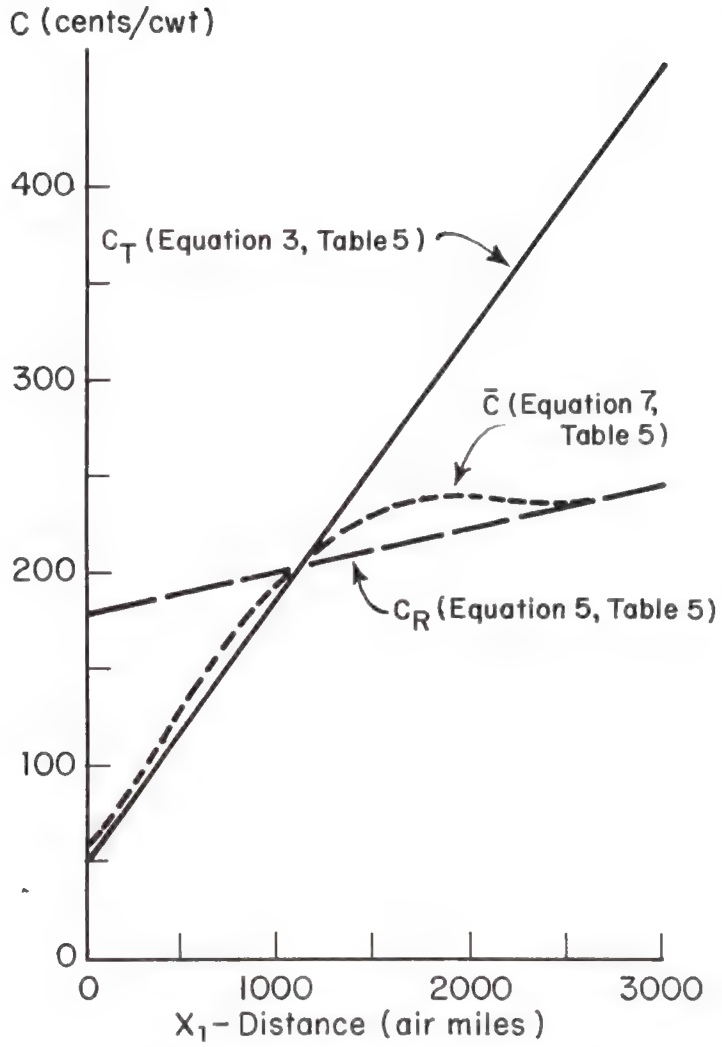

FIGURE 11. Combined Transfer Charge Relationship ($\bar{C}$) Obtained by Combining the Estimated Equation for Motor Carrier Charges (C_T) and Rail Carrier Charges (C_R) According to Mode-Use Equation 2 of Table 5

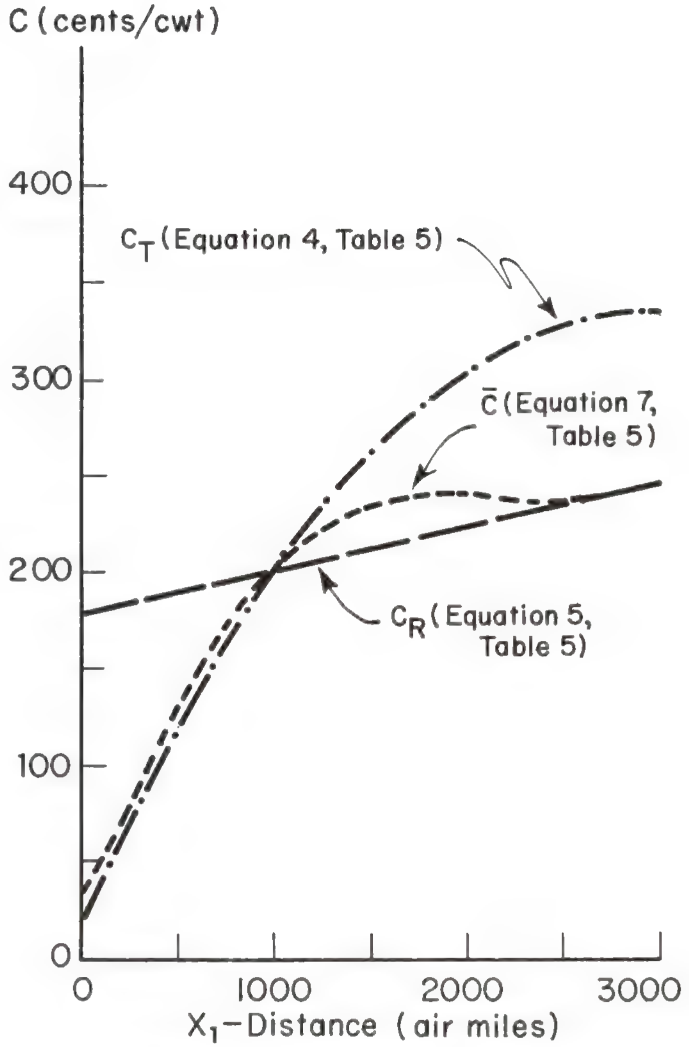

FIGURE 12. Combined Transfer Charge Relationship ($\bar{C}$) Obtained by Combining the Estimated Charges from a Curvilinear Equation for Motor Carrier Charges (C_T) and a Linear Equation for Rail Carrier Charges (C_R) According to the Percentage Shipments by Each Carrier

equipment and greater financial responsibility in case of loss or damage, even though truck rates are lower.[1] Therefore, an estimate of the effective transfer charge per hundredweight for frozen vegetables in that range would be somewhat higher than that given by the equation C_T. Referring to Figure 11, above 1,100 miles the combined transfer charge, $\overline{C}$, is higher than the rail charge, the difference being considerably greater than that between $\overline{C}$ and C_T in the lower ranges of distance. This implies that, even though the truck charges are above those for rail, some shippers do pay the higher charge, and the data for the mileage block of 1,501-2,000 miles in Table 4 show this is the case for a substantial amount of these shipments. Presumably, the higher charges are incurred in return for additional economic benefits derived. In addition to faster service, one of these factors is the cost of loading incurred by the shipper when shipping carload rail shipments. This charge is included in truck charges but not in rail charges and, therefore, is not explicitly included in equation (5). A rough estimate of this cost at 12 cents per hundredweight appeared justifiable to a large processor contacted. The difference between $\overline{C}$ and C_R in the range of 1,100-2,600 miles indicates the amount of charges shippers do incur for the additional economic benefits they receive, and the maximum difference may be taken as an indication of the amount above rail charges that they are willing to pay. If this is the case, then presumably they would be willing to pay this difference at greater distances if truck services could be obtained for that amount. The extension of $\overline{C}$ by equation (9b) in Figure 13 represents the amount shippers are willing to pay, part of which consists of the loading cost mentioned above. If the above statements have any validity, then one might argue that effective charges would tend to approach the function $\overline{C}$.

The alternative of explicitly including the additional cost of loading incurred for rail transport was also explored. The 12-cent approximation was added to equation (5) to obtain equation (6). Equations (2), (3), and (6) were then combined to obtain equation (8), which is presented graphically in Figure 14 along with equations (3) and (6). The primary difference between

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[1] U. S. Agricultural Marketing Service, Interstate Trucking of Frozen Fruits. . . .

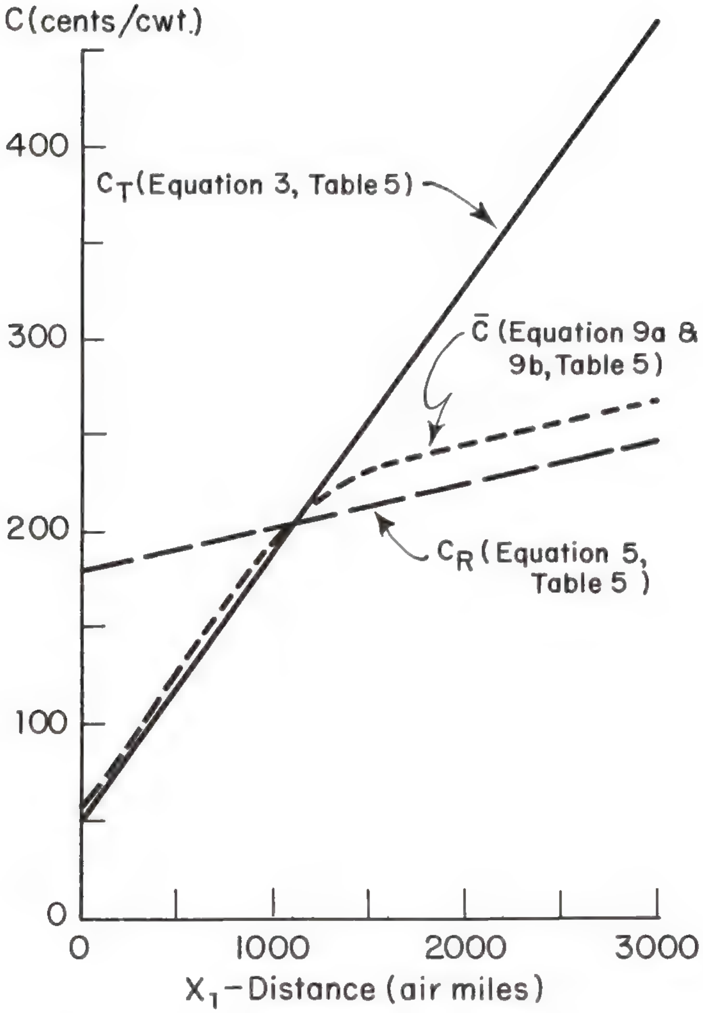

FIGURE 13. Combined Transfer Charge Relationship ($\bar{C}$) Obtained by Combining Estimated Motor Carrier (C_T) and Rail Carrier (C_R) Equations According to Mode-Use Equation 2 of Table 5 for Distances (X_1) up to Approximately 1,600 Miles and Extending the Relationship According to Equation 5 of Table 5 for Greater Distances

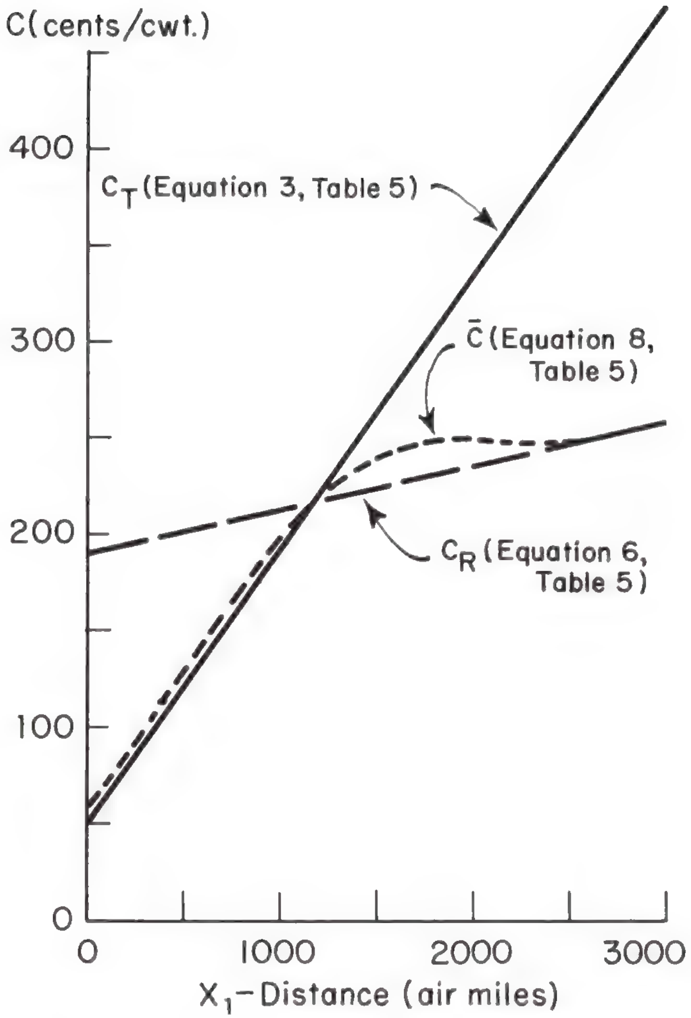

FIGURE 14. Combined Transfer Charge Relationship ($\bar{C}$) Obtained by Combining Estimated Motor Carrier (C_T) and Rail Carrier (C_R) Equations After Adding the Estimated 12-Cent Loading Charge to the Rail Carrier Equation

equations (7) and (8) is the fact that (8) decreases by a smaller amount in the range between its maximum and the point at which it reaches the equation C_R.[1]

The last suggested procedure explored was that of combining equations (3) and (6), using a linear approximation to the data of Table 4. However, the results were less adequate than earlier formulations and are not presented.

In summary, it is contended that the transfer charge relationships, such as those derived in this study from a sample of quoted charges, represent the effective charge per hundredweight only to the extent that the quoted charges are actually used, even if it is assumed that the derived relationships accurately represent the quoted charges. Data for frozen fruits and vegetables indicate that the effective charges may be equal to charges represented by the derived relationships only at very short and very long distances. Several attempts to incorporate the available data and derive more accurate estimates of the relationship of effective charges to distance were made, none of which resulted in completely acceptable results for estimation of transfer charges for use in an interregional study. Consequently, there appear to be three practical alternatives for using the derived results in estimating charges for frozen vegetables. These are: (1) use the combined equation (8) and attempt to justify the decreasing charges that occur with increasing distance; (2) use the combined equations (9a) and (9b) with its incomplete rationale; or (3) disregard the data of Table 4, recognizing the inaccuracy that may be introduced, and follow the usual procedure, employing equation (6) with equations (3) or (4) of Table 5 or equation 7 of Table 1.

Comparison With Other Studies

In the study by Dennis[2] a sample of motor carrier transportation rates and a sample of rail transportation rates between various states and selected cities were obtained for the year 1955 from a publication by the U. S. Department of Agriculture.[3] The rate between a given state and a given city is an average of the lowest published rates between each of several cities within the given state to the given city. The 1955 sample data for rail and for motor carrier were plotted against distance. To each scatter, least-squares techniques were employed to obtain a continuous function consisting of two equations, one for short distances and one for longer distances. These relationships are as follows:

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[1] Results obtained by substituting equation 7 of Table 1 with a minimum load weight of 33,000 pounds were essentially the same as those obtained in equation (8) of Table 5.

[2] Dennis, op. cit.

[3] U. S. Agricultural Marketing Service, Interstate Trucking of Frozen Fruits. . . .

Truck:

(1) $\log C = 0.677557 + 0.512363 \log D$; for $D \leq 415$

(2) $C = 57.776 + 0.112428D$; for $D > 415$

Rail:

(1) $C = 63.390745 + 0.108829D$; for $D \leq 1{,}000$

(2) $C = 166.970102 + 0.013027D$; for $D > 1{,}000$

where

C = charge per hundredweight.

D = distance in published highway mileage.[1]

The functions for rail and truck charges derived in the Dennis study were compared with equations (3) and (5), respectively, of Table 5, which were obtained from data for 1961-62. The former equations were adjusted, using equation 29 of Table 1, so as to be comparable on a mileage basis. Specifically, equation 29 was solved for X_2 (highway mileage = D), and the result was substituted for D in the equations obtained by Dennis. The results are shown graphically in Figures 15 and 16 for motor carrier and rail transport, respectively.

Except for the range from 0 to 300 miles, the functions for motor carrier charges have almost identical slopes, as shown in Figure 15. Of the three equations from Table 1 selected as possible alternative choices for use in estimating motor carrier charges, the equation used in the graphic representation probably offers the most direct comparison.[2] In addition, it appears more plausible on economic grounds than the quadratic form and possibly is more

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[1] Highway mileage obtained from Household Goods Carriers' Bureau, Mileage Guide No. 4. . . .

[2] Supra, p. 36.

FIGURE 15. A Graphic Comparison of Transfer Charge Relationships Derived from Data on Motor Carrier Charges in Independent Studies

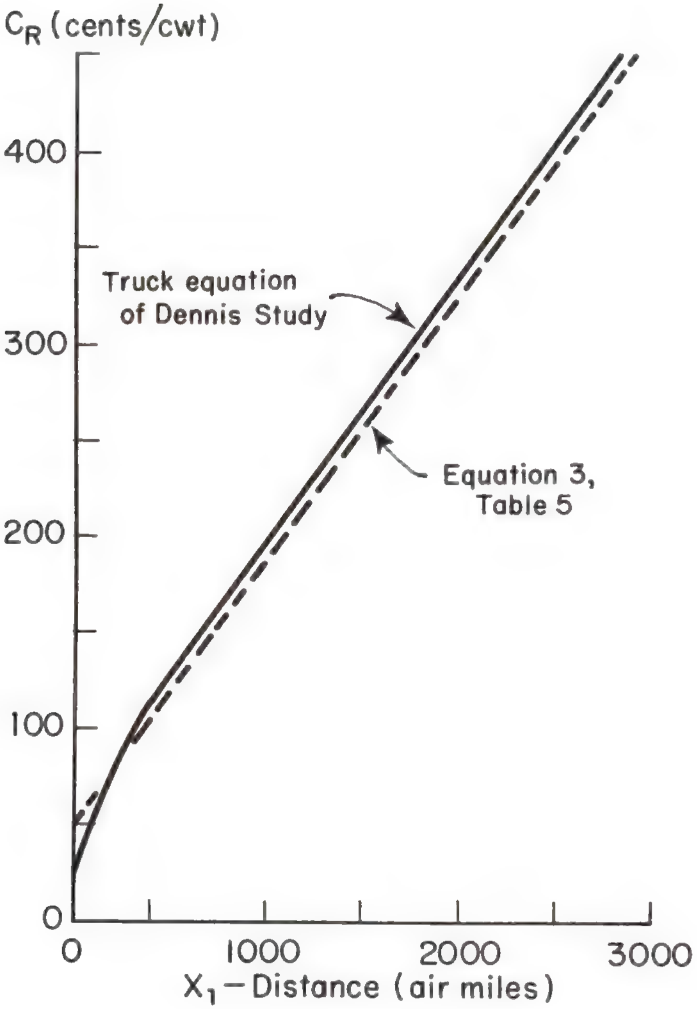
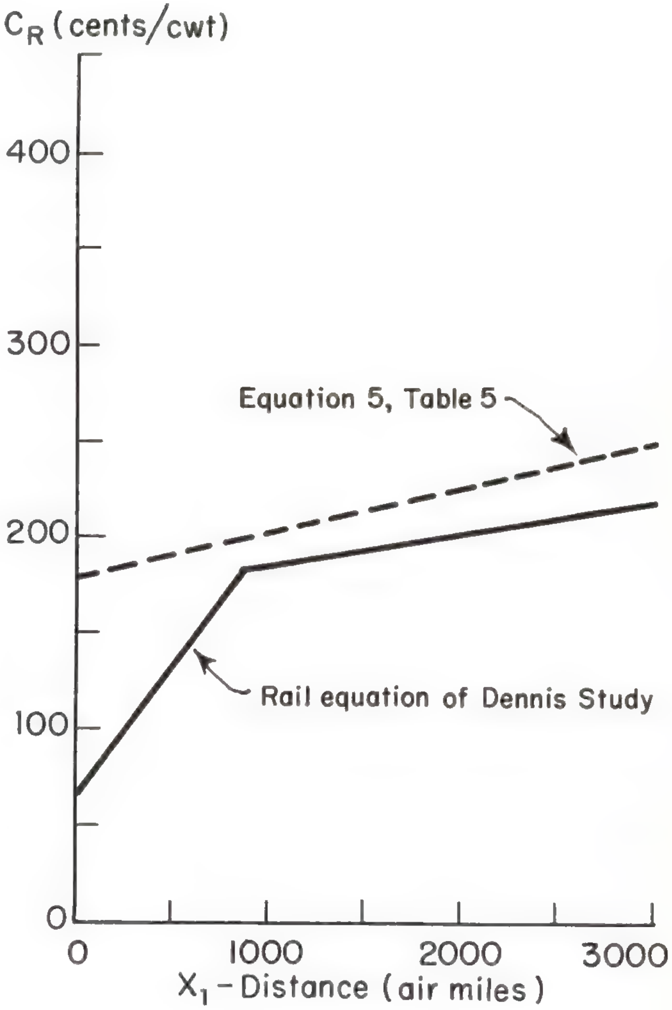


FIGURE 16. A Graphic Comparison of Transfer Charge Relationships Derived from Data on Rail Carrier Charges in Independent Studies



convenient for estimating charges than the alternative equation incorporating the full a priori cost specifications.

The level of the Dennis equation is approximately 7 cents higher for all distances greater than 200 miles. This is somewhat unexpected in that charges have probably increased since that function was obtained.[1/] A possible explanation of this phenomenon can be developed in terms of the weight variable; that is, the data and resulting empirical relations derived in the study by Dennis do not explicitly take into account the weight variable. Consequently, the level (intercept) and per mile charge (slope) of the derived relationship remain unchanged irrespective of changes in load weight. But the present study furnishes substantial evidence that charges per hundredweight are a decreasing function of weight, in addition to providing evidence that charges per mile are affected by load weight. The particular equation selected for comparison shows charges to be a monotonically decreasing function of minimum load weight, so that the level of the charge-distance relationship will vary inversely with minimum load weight. Thus, the graphic representation of this equation will lie above or below the equation with which it is compared depending on the selection of the value for minimum load weight (the two relationships will almost coincide at approximately 31,400 pounds). The graphic comparison is made for a minimum load weight of 33,000 pounds.

Although the basis for this choice of minimum load weight is somewhat arbitrary, it is not devoid of any justification. That is, under the condition of an inverse relationship of charges to minimum load weight as indicated in this equation, if the objective is to estimate the "least cost quoted charge," the largest possible minimum load weight should be selected. However, since the largest minimum load weight that appeared in the sample of observations was 40,000 pounds and there were a relatively small number of observations above 33,000 pounds as compared to the weight categories of 27,000-33,000 pounds and less than 27,000 pounds, it appeared that the upper limit of the 27,000-33,000 pound category was a more realistic compromise to the maximum of 40,000 pounds.[2/]

[1/] For evidence on general rate increases for the period 1958-1961, see the issues of U. S. Agricultural Marketing Service, The Marketing and Transportation Situation, MTS-129, 132, 135, 136, 139, and 140.

[2/] During 1957, it was estimated that the average truckload shipment of frozen fruits and vegetables was 32,000 pounds and the average rail carlot shipment was 64,000 pounds. See idem, Interstate Trucking of Frozen Fruits . . ., p. 32.

Thus, in accordance with the above reasoning, the equation obtained by Dennis would be expected to lie above the one with which it is compared simply because the former does not take into account the negative relationship of charges to weight. As a consequence, under similar circumstances one would expect to obtain a closer approximation to the "least cost" transfer charge by using the alternative equation. If one argues, perhaps with some justification, that a larger minimum load weight should be selected, the discrepancy between estimated charges for the two equations will be greater. Furthermore, the discrepancy would be even larger if one attempted to use the former equation to estimate charges for 1961-62 after making an adjustment for estimated rate increases. Moreover, since neither of the two equations takes into account the effect of the weight variable on the slope of the charge-distance relationship, an additional source of error is introduced.

With reference to the rail transfer charge functions of Figure 16, the comparative level of the functions are the reverse of the situation with truck functions. The function of the Dennis study has a somewhat smaller slope and a lower level. Part of the difference in the level of the functions is explained by increases in rates.[1] And, as with the motor carrier relationships, part of the difference in level is a result of the particular minimum load weight (60,000 pounds) selected for the graphic presentation. However, unlike the motor carrier equation, the rail equation has a U-shaped relationship of charges to weight, such that the graph of the equation would have been considerably below the equation obtained by Dennis if the minimum load weight had been set to correspond with the lowest point on the charge-weight relationship (the minimum point occurs at approximately 46,800 pounds).[2] In the lower distance range, the functions are not comparable.

Comparisons with results of other studies are limited more to methodological considerations and the form of the relationships fit to the data on transfer charges. Transportation charge relationships were estimated in a similar manner in two interregional studies by Farris and King, one on cucumbers and one on green peppers.[1] In both studies, regression techniques were used to derive equations from a relatively large sample of quoted rates. A quadratic equation in distance was obtained for rail charges, and a cubic equation in distance was obtained for truck charges. Linear equations were considered, but results were not presented. In analyzing exempt truck charges, a list of various cost factors is considered which are presumed to be determinants of charges. The R^2 values obtained were somewhat higher than those of the present study. For truck charges, the cubic equation increased at an increasing rate in the range of 1,500-2,000 miles.

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[1] Idem, The Marketing and Transportation Situation, MTS-129, 132, 135, 136, 139, and 140.

[2] Since a plotting of sample waybill data for 1959 against the relationship obtained by Dennis showed a large number of observations falling below the estimated relationship, if one uses the alternative relationship for estimating charges, selection of the minimum point for the equation of this study would probably lead to a closer approximation to actual charges.

On the basis of the present study, two questions might be raised. The first concerns the criteria on which the linear and quadratic forms were discarded. As noted in this study, with such a large number of observations most of the coefficients were significant regardless of the form of the relationship. Consequently, statistical measures did not provide a complete basis for deciding between various functional forms. The second question relates to the basis for the cubic equation. From the explanation of charges which increase at an increasing rate with distance, it appears that the basis for the functional form lies in the relationship of distance to the various cost factors as looked at from the viewpoint of the trucking firm. If this is the case, one might ask what the theoretical cost rationale is which specifies the cubic equation and eliminates the linear and quadratic forms.

Limitations and Usefulness of Results

There are several limitations of the empirical results in terms of their use for estimation of transfer charges. One of these relates to the inadequacy of the rail data and was discussed in that section. Briefly, the data were inadequate to test hypotheses about the a priori specifications and the coefficients of the equations obtained. Incomplete specification with the weight variable may also have introduced bias in the distance coefficients. Another limitation was the incomplete success in deriving acceptable relationships between the so-called effective charges and distance. If quoted charges equal the effective charges, then this limitation does not exist. Also related to this aspect is the relationship of quoted charges to actual charges for completed shipments. In view of the level of both the rail function of this study and the similar function of the Dennis study in relation to the waybill data, it appears that numerous special rates may exist for frozen vegetable shipments which make the quoted charges largely ineffective for such shipments.[1]

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[1] Donald E. Farris and Richard A. King, Interregional Competition in Marketing Slicing Cucumbers, North Carolina A. E. Information Series No. 78 (Raleigh, 1960), pp. 15-22.

Idem, Interregional Competition in Marketing Green Peppers, North Carolina A. E. Information Series No. 87 (Raleigh, 1961), pp. 14-19.

Although these limitations of the empirical results may exist, the results are still considered fairly accurate representations of the quoted charges and useful in obtaining estimates of such charges for point-to-point distances in an interregional study. The relatively high R^2 values and the small standard errors of the regression coefficients indicate relatively accurate predictive ability for quoted charges.

The methodological approach was an attempt to incorporate economic theory and statistical techniques in the derivation of transfer charge relationships. This approach proved useful as a starting point for suggesting various alternative functional relationships and also in the evaluation of the alternative formulations derived from the data. The limitations, or conversely the validity, of the methodology are largely dependent on the degree to which the various incorporated assumptions are valid, and this is not presently known. The essential assumptions were concerned with the relationship of costs to charges, which depends on the nature of competition in the industry and the importance of costs in the establishment of charges. And while there is some justification for the a priori specifications, their verification is still an unanswered question. Another limitation which is not dependent on the above assumptions but is related to the statistical technique employed is in part inconsistent with the objectives. Because the least-squares regression line is inherently an average relationship, the predicted values will not necessarily be the least-cost charges in a strict sense.

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[1] U. S. Interstate Commerce Commission, Carload Waybill Statistics, 1959: . . ., pp. 84-85.

Idem, Carload Waybill Statistics: Mileage Block Distribution, Products of Agriculture, Statement MB-1, September, 1960, pp. 60-61.

Summary

The primary purpose of this investigation was to obtain transfer charges for an interregional study concerning frozen vegetables. Subsidiary to this objective was that of examining more closely certain analytical techniques that have been employed for such purposes in an attempt to evaluate their usefulness, validity, and accuracy for the estimation of transfer charges in this and similar studies.

Relevant background material concerning the general structure of rates and charges; their establishment; and their relation to cost determinants such as distance, weight, etc., is presented. Utilizing readily available data, preliminary investigation of the transport charge relations obtained in an earlier interregional study served as a partial basis for directing the present study. This preliminary investigation raised the question regarding the rationale for applying functional relationships to transfer charges.

A consideration of industry structure, economic theory, and previous studies suggested that the ultimate basis was the underlying economic cost of the transportation service. An attempt was made to develop a priori cost specifications in terms of variables for which data were available. These specifications served as the primary basis for selecting various functional forms to be applied to the data using regression techniques. The form of the relations was altered to incorporate various hypotheses suggested in other publications.

Inadequate data on rail charges limited the hypotheses which could be tested with those results. In general, it was felt that the overall results were favorable and that useful relationships were obtained. Data on shipments of frozen fruits and vegetables indicated that relationships derived from quoted charges and used in the usual manner for estimating charges may not give accurate estimates of the actual charges required for an interregional study. In other words, quoted charges may not constitute the relevant transfer charges or "effective charges" for certain point-to-point distance. However, attempts to incorporate these data resulted in very limited success. In terms of the initial objectives, a choice of relationships for estimating charges for frozen vegetables is presented. And while these relationships have inherent limitations, they are felt to be as good as could be obtained from the available data. In addition, certain suggestions are made and certain questions raised that may prove to be both helpful and troublesome in similar studies.

APPENDIX

Data on Rates and Charges for Frozen Vegetables Used in Estimation of Transportation Charge Relationships

Origins and Destinations

The following origin and destination points were used for obtaining distance measurements and transportation charges for rail and motor carrier. These cities were selected as production centers (origin points) and consumption centers for frozen vegetables by Melvin Wagner. In order to avoid repetition and save space in presenting the data, the origin and destination points are listed here and given a letter subscript and numerical designation. The origin points have a subscript "j," where j = 1, ..., 14; and the destination points have subscript "i," where i = 1, ..., 49.

Origin points

j		j	
1	Seattle, Washington	8	Tampa, Florida
2	Albany, Oregon	9	Salisbury, Maryland
3	Watsonville, California	10	Seabrook, New Jersey
4	Corpus Christi, Texas	11	Gloucester, Massachusetts
5	Fairmont, Minnesota	12	Rochester, New York
6	Saginaw, Michigan	13	Green Bay, Wisconsin
7	Jackson, Tennessee	14	Fort Smith, Arkansas

Destination points

i		i	
1	Portland, Maine	26	Jackson, Mississippi
2	Concord, New Hampshire	27	Little Rock, Arkansas
3	Burlington, Vermont	28	Baton Rouge, Louisiana
4	Boston, Massachusetts	29	Oklahoma City, Oklahoma
5	Providence, Rhode Island	30	Waco, Texas
6	New Haven, Connecticut	31	Albuquerque, New Mexico
7	Albany, New York	32	Jefferson,City, Missouri
8	Trenton, New Jersey	33	Des Moines, Iowa
9	Dover, Delaware	34	Madison, Wisconsin
10	Baltimore, Maryland	35	Minneapolis, Minnesota
11	Harrisburg, Pennsylvania	36	Jamestown, North Dakota
12	Richmond, Virginia	37	Sioux Falls, South Dakota
13	Charleston, West Virginia	38	Omaha, Nebraska
14	Sandusky, Ohio	39	Wichita, Kansas
15	Indianapolis, Indiana	40	Denver, Colorado
16	Chicago, Illinois	41	Casper, Wyoming
17	Lansing, Michigan	42	Lewistown, Montana
18	Washington, D. C.	43	Boise, Idaho
19	Raleigh, North Carolina	44	Salt Lake City, Utah
20	Columbia, South Carolina	45	Phoenix, Arizona
21	Macon, Georgia	46	Bakersfield, California
22	Tampa, Florida	47	Reno, Nevada
23	Louisville, Kentucky	48	Salem, Oregon
24	Nashville, Tennessee	49	Seattle, Washington
25	Birmingham, Alabama		

APPENDIX TABLE 1

Motor Carrier Transfer Charges with Corresponding Minimum Load Weights for Frozen Vegetables Between 14 Points of Origin and 49 Destination Points in the United States, 1961-62

Transfer charges--C_{ijk} a/			
i	j	k	C
1	5	36	243.0
1	7	25	294.0
1	8	27	305.0
1	8	27	213.0
1	10	30	90.0
2	5	36	243.0
2	7	25	284.0
2	8	27	297.0
2	8	27	212.0
2	10	30	100.0
3	5	36	243.0
3	7	25	276.0
3	8	27	297.0
3	8	27	220.0
3	10	30	100.0
4	5	30	255.0
4	5	36	237.0
4	7	25	287.0
4	8	26	225.0
4	8	31	179.0
4	9	21	106.0
4	9	28	100.0
4	10	24	78.0
4	10	30	74.0
4	10	30	73.0
5	5	36	237.0
5	7	25	287.0
5	8	26	224.0
5	8	31	179.0
5	9	21	103.0
5	9	28	98.0
5	10	24	76.0
5	10	30	72.0
5	10	30	71.0
6	5	36	237.0
6	7	25	273.0
6	8	26	211.0
6	8	31	179.0
6	9	21	88.0
6	9	28	83.0
6	10	24	63.0
6	10	30	59.0
6	10	30	58.0
7	5	36	217.0
7	7	25	259.0
7	8	27	219.0
7	8	31	185.0
7	8	27	214.0
7	10	24	70.0
7	10	30	66.0
7	10	30	65.0
8	5	36	228.0
8	7	25	253.0
8	8	25	256.0
8	8	31	170.0
8	8	27	198.0
8	9	23	53.0
8	10	30	36.0
9	5	20	231.0
9	7	25	248.0
9	8	26	184.0
9	8	27	179.0
9	8	27	189.0
9	9	23	38.0
9	10	30	48.0
10	5	30	235.0
10	5	20	219.0
10	7	25	235.0
10	8	26	183.0
10	8	31	162.0
10	8	27	188.0
10	9	23	53.0
10	10	24	55.0
10	10	30	52.0
10	10	30	48.0
10	11	24	99.0
10	12	23	76.0
11	5	20	211.0
11	7	25	238.0
11	8	26	193.0
11	8	27	187.0
11	8	27	193.0
11	10	24	55.0
11	10	30	52.0
11	10	30	51.0
12	5	27	247.0
12	5	20	220.0
12	7	24	191.0
12	8	27	175.0
12	8	20	198.0
12	8	24	165.0
12	8	27	159.0
12	9	23	65.0
12	10	24	72.0
12	10	30	68.0
12	10	30	67.0
12	12	24	123.0
13	1	33	270.0
13	2	33	270.0
13	3	33	270.0
13	5	30	162.0
13	7	25	175.0
13	8	20	228.0
13	8	24	190.0
13	8	27	179.0
13	8	27	189.0
13	10	30	88.0
14	1	33	270.0
14	2	33	270.0
14	3	33	270.0
14	5	30	182.0
14	8	20	250.0
14	8	24	208.0
14	8	27	190.0
14	8	27	204.0
14	10	30	86.0
15	1	10	475.0
15	1	33	240.0
15	2	10	475.0
15	2	33	240.0
15	2	33	270.0
15	3	10	475.0
15	3	33	240.0
15	3	33	270.0
15	5	30	139.0
15	8	20	236.0
15	8	24	197.0
15	8	27	182.0
15	8	27	183.0
15	8	27	193.0
15	10	30	100.0
16	1	10	425.0
16	1	33	225.0
16	2	10	425.0
16	2	33	225.0
16	3	10	425.0
16	3	33	225.0
16	5	36	81.0
16	8	20	252.0
16	8	24	210.0
16	8	27	194.0
16	8	27	191.0
16	8	27	205.0
16	10	30	101.0
16	13	24	50.0
16	13	42	48.0
16	14	20	193.0
16	14	28	162.0
17	1	33	245.0
17	2	33	245.0
17	3	33	210.0
17	3	33	245.0
17	5	30	163.0
17	8	27	193.0
17	8	27	209.0
17	10	30	99.0
17	13	30	116.0
18	5	30	232.0
18	5	20	219.0
18	7	25	228.0
18	8	26	179.0
18	8	31	162.0
18	9	23	59.0
18	10	24	59.0
18	10	30	55.0
18	10	30	54.0
18	11	23	107.0
18	12	23	93.0
19	7	24	186.0
19	8	20	185.0
19	8	24	154.0
19	8	27	149.0
19	9	25	137.0
19	10	25	156.0
19	10	30	73.0
19	11	25	210.0
19	12	25	193.0
20	7	24	158.0
20	8	20	164.0
20	8	24	137.0
20	8	27	134.0
20	9	25	172.0
20	10	25	190.0
20	10	30	104.0
20	11	25	238.0
20	12	25	224.0
21	7	24	138.0
21	8	20	157.0
21	8	24	131.0
21	8	27	129.0

(Continued on next page.)

APPENDIX TABLE 1--continued.

Transfer charges--C_{ijk} a/																			
i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C
21	9	25	200.0	24	10	30	144.0	27	8	27	184.0	32	8	27	191.0	35	5	30	36.0
21	10	25	224.0	24	11	25	273.0	27	10	30	165.0	32	8	27	202.0	35	5	27	36.0
21	10	30	120.0	24	12	25	210.0	28	1	24	465.0	33	1	10	430.0	35	8	20	294.0
21	11	25	266.0	25	1	24	487.0	28	2	24	465.0	33	1	33	200.0	35	8	24	245.0
21	12	25	248.0	25	2	24	487.0	28	3	28	250.0	33	1	33	190.0	35	8	27	227.0
22	4	24	223.0	25	3	24	487.0	28	8	27	163.0	33	2	10	430.0	35	8	27	219.0
22	5	36	238.0	25	5	26	179.0	28	8	27	172.0	33	2	33	200.0	35	8	27	234.0
22	7	24	182.0	25	7	24	95.0	28	10	30	185.0	33	2	33	190.0	35	10	30	182.0
22	9	25	235.0	25	8	20	176.0	29	1	30	256.0	33	3	10	430.0	36	1	33	200.0
22	10	25	259.0	25	8	24	147.0	29	2	30	256.0	33	3	33	200.0	36	1	33	216.0
22	10	30	143.0	25	8	27	144.0	29	3	30	206.0	33	3	33	190.0	36	2	33	200.0
22	11	25	301.0	25	8	27	150.0	29	5	26	187.0	33	5	30	92.0	36	2	33	216.0
22	12	25	287.0	25	9	25	228.0	29	5	28	177.0	33	5	30	91.0	36	3	33	205.0
22	12	27	213.0	25	10	25	235.0	29	5	28	146.0	33	8	27	208.0	36	3	33	200.0
22	12	27	227.0	25	10	30	139.0	29	8	20	275.0	33	8	20	275.0	36	3	33	216.0
23	1	10	475.0	25	11	25	276.0	29	8	24	229.0	33	8	24	229.0	36	5	30	141.0
23	1	33	240.0	25	12	25	238.0	29	8	27	212.0	33	8	27	212.0	36	8	27	256.0
23	2	10	475.0	26	1	24	465.0	29	8	27	215.0	33	8	27	220.0	36	8	27	259.0
23	2	33	240.0	26	2	24	465.0	29	8	27	212.0	33	14	20	165.0	37	1	33	200.0
23	3	10	475.0	26	3	24	441.0	29	10	30	186.0	33	14	28	145.0	37	1	33	216.0
23	3	33	240.0	26	5	26	195.0	30	1	24	465.0	34	1	10	452.0	37	2	33	200.0
23	5	30	151.0	26	7	24	102.0	30	2	24	465.0	34	1	33	225.0	37	2	33	216.0
23	7	24	113.0	26	8	20	194.0	30	3	28	240.0	34	2	10	452.0	37	3	33	205.0
23	8	27	184.0	26	8	24	162.0	30	4	26	87.0	34	2	33	225.0	37	3	33	200.0
23	8	20	220.0	26	8	27	158.0	30	5	20	271.0	34	3	10	452.0	37	3	33	216.0
23	8	24	183.0	26	9	25	261.0	30	8	27	205.0	34	3	33	225.0	37	5	30	84.0
23	8	27	172.0	26	10	25	269.0	30	8	27	204.0	34	5	28	85.0	37	8	27	227.0
23	10	30	102.0	26	10	30	162.0	30	10	30	200.0	34	5	30	81.0	37	8	27	237.0
24	1	24	487.0	26	11	25	311.0	31	1	24	437.0	34	8	20	286.0	38	1	10	425.0
24	2	24	487.0	26	12	25	266.0	31	2	24	437.0	34	8	24	238.0	38	1	33	190.0
24	3	24	487.0	27	1	24	441.0	31	3	30	246.0	34	8	27	220.0	38	2	10	425.0
24	5	26	156.0	27	2	24	441.0	31	3	30	211.0	34	8	27	197.0	38	2	33	190.0
24	7	24	82.0	27	3	28	245.0	31	5	33	267.0	34	8	27	216.0	38	3	10	425.0
24	8	24	179.0	27	5	26	161.0	31	10	30	230.0	35	1	33	200.0	38	3	33	190.0
24	8	27	170.0	27	5	20	212.0	32	1	33	225.0	35	2	33	200.0	38	5	30	61.0
24	8	27	160.0	27	8	20	224.0	32	2	33	225.0	35	3	33	205.0	38	5	36	55.0
24	9	25	235.0	27	8	24	187.0	32	3	33	225.0	35	3	33	200.0	38	8	20	281.0
24	10	25	235.0	27	8	27	173.0	32	5	30	147.0	35	5	36	27.0	38	8	24	234.0

(Continued on next page.)

APPENDIX TABLE 1--continued.

Transfer charges--C_{ijk}[a]																			
i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C
38	8	27	216.0	40	1	30	209.0	42	1	15	261.0	44	3	36	163.0	47	5	33	267.0
38	8	27	214.0	40	1	32	198.0	42	1	30	209.0	44	3	38	234.0	47	5	30	271.0
38	8	27	225.0	40	2	38	185.0	42	1	36	199.0	44	5	33	230.0	47	13	30	403.0
38	9	30	233.0	40	2	20	271.0	42	2	33	199.0	44	5	30	271.0	48	1	35	139.0
38	10	30	154.0	40	2	25	249.0	42	3	36	311.0	45	1	36	205.0	48	1	37	55.0
38	14	20	154.0	40	2	30	209.0	42	3	33	199.0	45	2	36	179.0	48	2	20	19.0
38	14	28	137.0	40	2	32	198.0	42	3	36	296.0	45	3	20	225.0	48	2	30	16.0
39	1	10	425.0	40	3	20	258.0	42	5	30	280.0	45	3	30	199.0	48	3	36	140.0
39	1	33	190.0	40	3	25	237.0	43	1	35	130.0	45	3	30	198.0	48	5	33	271.0
39	2	10	425.0	40	3	38	185.0	43	1	10	272.0	45	3	40	165.0	48	5	30	280.0
39	2	33	190.0	40	5	25	193.0	43	1	15	217.0	45	5	33	267.0	49	2	10	169.0
39	3	10	425.0	40	5	25	195.0	43	2	35	130.0	45	5	30	271.0	49	2	15	130.0
39	3	33	190.0	40	5	30	234.0	43	3	36	214.0	45	13	30	395.0	49	2	76	55.0
39	5	30	183.0	41	1	38	185.0	43	3	40	209.0	46	1	35	153.0	49	3	10	324.0
39	8	20	283.0	41	2	38	185.0	43	3	36	263.0	46	2	35	121.0	49	3	20	298.0
39	8	27	220.0	41	3	36	271.0	43	5	33	271.0	46	3	36	62.0	49	3	36	161.0
39	8	24	236.0	41	3	20	339.0	43	5	30	280.0	46	5	33	267.0	49	5	33	271.0
39	8	27	218.0	41	3	30	282.0	44	1	15	217.0	46	5	30	271.0	49	5	30	280.0
39	8	27	217.0	41	5	25	195.0	44	1	36	163.0	46	6	30	385.0				
40	1	38	185.0	41	5	30	226.0	44	2	36	167.0	47	1	36	179.0				
40	1	20	271.0	41	8	27	356.0	44	2	36	163.0	47	2	36	152.0				
40	1	25	249.0	42	1	33	199.0	44	3	38	175.0	47	3	35	89.0				

[a] C = motor carrier transfer charge, cents per hundredweight; i = destination point; j = point of origin; and k = minimum load weight, thousand pounds.

APPENDIX TABLE 2

Railroad Transfer Charges (Sample A, Including Refrigeration Charges) for Frozen Vegetables with Corresponding Minimum Load Weights Between 14 Points of Origin and 49 Destination Points in the United States, 1961-62

Transfer charges--C_{ijk}[a]																			
i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C
1	1	60	228.3	7	4	60	226.4	14	2	60	217.6	20	8	36	130.4	27	5	36	198.3
1	2	60	228.3	7	5	50	160.5	14	3	60	217.6	21	1	60	226.4	27	8	36	181.4
1	3	60	228.3	7	8	36	173.0	14	4	60	219.1	21	2	60	226.4	28	1	60	207.6
1	4	60	228.3	8	1	60	226.4	14	5	36	179.9	21	3	60	226.4	28	2	60	207.6
1	5	50	163.8	8	2	60	226.4	14	8	36	187.4	21	4	60	217.2	28	3	60	201.5
1	8	36	183.3	8	3	60	226.4	15	1	60	211.5	21	8	36	125.4	28	4	60	196.9
2	1	60	228.3	8	4	60	226.4	15	2	60	211.5	22	1	60	228.3	28	5	60	204.8
2	2	60	228.3	8	5	50	160.5	15	3	60	211.5	22	2	60	228.3	28	8	36	160.0
2	3	60	228.3	8	8	36	164.4	15	4	60	212.2	22	3	60	228.3	29	1	60	203.8
2	4	60	228.3	9	1	60	226.4	15	5	50	104.8	22	4	60	241.4	29	2	60	203.8
2	5	50	163.8	9	2	60	226.4	15	8	36	180.4	23	1	60	211.5	29	3	60	191.8
3	1	60	228.3	9	3	60	226.4	16	1	60	206.5	23	2	60	211.5	29	5	36	181.3
3	2	60	228.3	9	4	60	226.4	16	2	60	206.5	23	3	60	211.5	29	7	60	210.7
3	3	60	228.3	9	8	36	162.4	16	3	60	206.5	23	4	60	212.2	29	8	36	213.5
3	4	60	228.3	10	1	60	226.4	16	4	60	207.2	23	5	50	114.8	29	9	60	228.3
3	5	50	163.8	10	2	60	226.4	16	5	50	72.2	23	8	36	168.9	29	10	60	228.3
3	8	36	186.3	10	3	60	226.4	16	8	36	188.4	24	1	60	211.5	29	11	60	228.3
4	1	60	228.3	10	4	60	226.4	17	1	60	212.6	24	2	60	211.5	29	12	60	224.5
4	2	60	228.3	10	5	50	160.5	17	2	60	212.6	24	3	60	211.5	30	1	60	206.5
4	3	60	228.3	10	8	36	157.4	17	3	60	212.6	24	4	60	210.3	30	2	60	206.5
4	4	60	228.3	11	1	60	226.4	17	4	60	214.1	24	5	50	126.8	30	3	60	191.8
4	5	50	163.8	11	2	60	226.4	17	5	36	164.9	24	8	36	156.9	30	5	60	197.9
4	8	36	173.0	11	3	60	226.4	17	8	36	190.4	25	1	60	214.5	30	7	60	210.7
5	1	60	228.3	11	4	60	226.4	18	1	60	226.4	25	2	60	214.5	30	8	36	202.4
5	2	60	228.3	11	5	50	160.5	18	2	60	226.4	25	3	60	214.5	30	9	60	230.2
5	3	60	228.3	11	8	36	165.0	18	3	60	226.4	25	4	60	210.3	30	10	60	230.2
5	4	60	228.3	12	1	60	226.4	18	4	60	226.4	25	5	60	209.8	30	11	60	230.2
5	5	50	163.8	12	2	60	226.4	18	5	50	160.5	25	8	36	140.2	30	12	60	226.4
5	8	36	173.0	12	3	60	226.4	18	8	36	157.4	26	1	60	206.5	31	1	60	201.9
6	1	60	228.3	12	4	60	226.4	19	1	60	226.4	26	2	60	206.5	31	2	60	201.9
6	2	60	228.3	12	8	36	154.4	19	2	60	226.4	26	3	60	201.5	31	3	60	188.8
6	3	60	228.3	13	1	60	217.6	19	3	60	226.4	26	4	60	199.2	31	5	60	199.8
6	4	60	228.3	13	2	60	217.6	19	4	60	224.1	26	5	60	204.8	31	7	60	218.3
6	5	50	162.8	13	3	60	217.6	19	8	36	145.4	26	8	36	155.0	31	8	60	245.2
6	8	36	173.0	13	4	60	219.1	20	1	60	226.4	27	1	60	206.5	31	9	60	234.0
7	1	60	226.4	13	5	50	157.1	20	2	60	226.4	27	2	60	206.5	31	10	60	234.0
7	2	60	226.4	13	8	36	176.8	20	3	60	226.4	27	3	60	201.5	31	11	60	234.0
7	3	60	226.4	14	1	60	217.6	20	4	60	224.1	27	4	60	196.9	31	2	60	230.2

(Continued on next page.)

APPENDIX TABLE 2--continued.

Transfer charges--C_{ijk}[a]																			
i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C
32	1	60	201.5	38	3	60	191.8	42	9	60	235.9	46	7	60	220.2	49	12	60	234.0
32	2	60	201.5	38	5	50	52.5	42	10	60	234.0	46	8	60	249.0	49	13	60	211.4
32	3	60	201.5	38	6	36	191.0	42	11	60	235.9	46	9	60	237.8				
32	5	36	147.7	38	8	36	212.5	42	12	60	232.1	46	10	60	237.8				
32	6	36	178.0	39	1	60	201.9	42	13	60	207.6	46	11	60	237.8				
32	8	36	195.6	39	2	60	201.9	43	5	60	200.7	46	12	60	234.0				
33	1	60	198.8	39	3	60	189.9	43	6	60	218.3	46	13	60	211.4				
33	2	60	198.8	39	5	50	100.0	43	7	60	220.2	47	5	60	202.6				
33	3	60	198.8	39	6	60	210.7	43	8	60	247.1	47	6	60	220.2				
33	5	50	50.0	39	8	36	218.7	43	9	60	235.9	47	7	60	218.3				
33	6	36	173.0	40	1	60	188.8	43	10	60	234.0	47	8	60	249.0				
33	8	36	206.5	40	2	60	188.8	43	11	60	235.9	47	9	60	237.8				
34	1	60	206.5	40	3	60	188.8	43	12	60	232.1	47	10	60	235.9				
34	2	60	206.5	40	5	50	114.0	43	13	60	209.5	47	11	60	237.8				
34	3	60	206.5	40	6	60	212.6	44	5	60	198.8	47	12	60	234.0				
34	4	60	207.2	40	7	60	214.5	44	6	60	216.4	47	13	60	211.4				
34	5	36	124.1	40	8	60	243.3	44	7	60	216.4	48	1	40	74.3				
34	8	36	194.4	40	9	60	230.2	44	8	60	245.2	48	3	50	110.8				
35	1	60	191.8	40	10	60	230.2	44	9	60	234.0	48	4	60	211.4				
35	2	60	191.8	40	11	60	230.2	44	10	60	232.1	48	5	60	202.6				
35	3	60	201.5	40	12	60	226.4	44	11	60	234.0	48	6	60	220.2				
35	5	50	55.0	40	13	60	205.7	44	12	60	230.2	48	7	60	222.1				
35	6	36	161.0	40	14	60	189.9	44	13	60	207.6	48	8	60	250.9				
35	8	36	217.8	41	1	60	188.8	45	1	50	157.1	48	9	60	237.8				
36	1	60	189.9	41	2	60	188.8	45	5	60	203.6	48	10	60	235.9				
36	2	60	189.9	41	3	60	190.9	45	6	60	220.2	48	11	60	237.8				
36	3	60	201.5	41	5	36	186.3	45	7	60	222.1	48	12	60	234.0				
36	5	36	136.1	41	6	60	212.6	45	8	60	245.2	48	13	60	211.4				
36	6	36	209.4	41	7	60	216.4	45	9	60	237.8	49	2	40	93.0				
36	8	60	245.2	41	8	60	247.1	45	10	60	235.9	49	3	50	122.8				
37	1	60	189.9	41	9	60	232.1	45	11	60	237.8	49	4	60	211.4				
37	2	60	189.9	41	10	60	230.2	45	12	60	234.0	49	5	60	202.6				
37	3	60	201.5	41	11	60	232.1	45	13	60	211.4	49	6	60	220.2				
37	5	36	94.5	41	12	60	228.3	46	1	50	124.8	49	7	60	222.1				
37	6	36	191.2	41	13	60	205.7	46	2	50	120.3	49	8	60	250.9				
37	8	36	225.9	42	6	60	218.3	46	4	60	197.1	49	9	60	237.8				
38	1	60	191.8	42	7	60	220.2	46	5	60	204.5	49	10	60	235.9				
38	2	60	191.8	42	8	60	248.6	46	6	60	220.2	49	11	60	237.8				

[a] C = transfer charge, cents per hundredweight; i = destination point; j = point of origin; and k = minimum load weight, thousand pounds.

APPENDIX TABLE 3

Railroad Rates (Sample B, Excluding Refrigeration Charges) for Frozen Vegetables with Corresponding Minimum Load Weights Between 14 Points of Origin and 49 Destination Points in the United States, 1961-62

Railroad rates--C_{ijk}[a]																			
i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C	i	j	k	C
1	5	50	133.0	9	13	36	178.0	19	5	36	210.0	32	14	36	106.0	43	7	60	186.0
1	7	36	220.0	9	14	36	220.0	19	13	36	189.0	33	5	36	114.0	43	13	30	208.0
1	13	36	189.0	10	4	60	196.0	19	14	36	195.0	33	13	36	116.0	43	13	46	191.0
1	14	46	226.0	10	5	50	132.0	20	5	36	207.0	33	14	36	127.0	43	13	70	168.0
2	5	50	133.0	10	7	36	175.0	20	13	36	186.0	34	5	36	94.0	43	14	30	208.0
2	7	36	212.0	10	13	36	174.0	20	14	36	176.0	34	13	36	63.5	43	14	46	191.0
2	13	36	181.0	10	14	36	210.0	21	5	36	199.0	34	14	36	153.0	43	14	60	181.0
2	14	46	226.0	11	4	60	196.0	21	13	36	184.0	35	5	36	71.0	43	14	70	168.0
3	5	50	133.0	11	5	50	132.0	21	14	36	160.0	35	13	36	94.0	44	5	70	162.0
3	7	36	207.0	11	7	36	178.0	22	5	36	236.0	35	14	36	160.0	44	13	30	208.0
3	13	36	176.0	11	13	36	166.0	22	13	36	223.0	36	5	36	106.0	44	13	46	191.0
3	14	46	226.0	11	14	36	210.0	22	14	36	192.0	36	13	36	137.0	44	13	70	168.0
4	4	60	196.0	12	4	60	196.0	23	5	36	145.0	36	14	36	178.0	44	14	36	252.0
4	5	50	133.0	12	5	50	133.0	23	13	36	123.0	37	5	36	67.0				
4	7	36	215.0	12	7	60	144.0	23	14	36	145.0	37	13	36	122.0				
4	13	36	181.0	12	13	36	184.0	24	5	36	158.0	37	14	36	147.0				
4	14	46	226.0	12	14	36	199.0	24	13	36	139.0	38	5	50	31.5				
5	5	50	133.0	13	13	36	142.0	24	14	36	127.0	38	7	36	145.0				
5	7	36	215.0	14	5	36	145.0	25	5	36	178.0	38	13	36	129.0				
5	13	36	181.0	14	7	36	135.0	25	13	36	168.0	38	14	36	122.0				
5	14	46	226.0	14	13	36	112.0	25	14	36	129.0	39	5	50	76.0				
6	5	50	132.0	14	14	36	171.0	26	5	36	181.0	39	7	36	139.0				
6	7	36	210.0	15	4	60	196.0	26	13	36	174.0	39	13	36	160.0				
6	13	36	176.0	15	5	36	132.0	26	14	36	112.0	39	14	36	94.0				
6	14	46	226.0	15	7	36	106.0	27	5	36	166.0	40	5	36	184.0				
7	4	60	196.0	15	13	36	106.0	27	13	36	160.0	40	13	36	192.0				
7	5	50	132.0	15	14	36	142.0	27	14	36	70.0	40	14	36	163.0				
7	7	36	195.0	16	5	50	75.0	28	5	36	186.0	41	5	36	153.0				
7	13	36	163.0	16	7	36	116.0	28	13	36	192.0	41	7	36	207.0				
7	14	36	226.0	16	13	36	78.0	28	14	36	122.0	41	13	36	192.0				
8	4	60	196.0	16	14	36	147.0	29	5	36	150.0	41	14	36	178.0				
8	5	50	132.0	17	13	36	89.0	29	13	36	176.0	42	5	70	162.0				
8	7	36	190.0	18	4	60	196.0	29	14	36	84.0	42	13	30	208.0				
8	13	36	174.0	18	5	50	132.0	30	13	36	199.0	42	13	40	191.0				
8	14	36	223.0	18	7	36	171.0	31	13	36	228.0	42	13	70	168.0				
9	4	60	196.0	18	13	36	171.0	32	5	36	116.0	42	14	36	264.0				
9	7	36	187.0	18	14	36	205.0	32	13	36	132.0	43	5	70	168.0				

[a] C = railroad rate, cents per hundredweight; i = destination point; j = point of origin; and k = minimum load weight, thousand pounds.

APPENDIX TABLE 4

Airline Distance Between 14 Points of Origin and 49 Destination Points

Destination	Origin													
	1	2[a]	3[a]	4	5[a]	6	7	8	9[a]	10[a]	11[a]	12	13	14
	miles													
1	2,490	2,581	2,721	1,863	1,196	686	1,131	1,278	459	385	74	371	884	1,405
2	2,445	2,531	2,661	1,791	1,137	624	1,060	1,216	437	317	58	306	826	1,334
3	2,333	2,423	2,568	1,763	1,048	539	1,026	1,249	438	357	178	238	730	1,284
4	2,493	2,576	2,694	1,787	1,177	657	1,060	1,182	366	290	28	338	864	1,343
5	2,493	2,573	2,682	1,755	1,162	647	1,031	1,142	325	253	68	330	857	1,317
6	2,439	2,514	2,610	1,668	1,097	582	945	1,067	248	173	147	272	795	1,233
7	2,360	2,440	2,555	1,674	1,035	518	942	1,125	313	231	157	199	726	1,216
8[a]	2,394	2,460	2,522	1,551	1,032	525	831	957	137	56	265	251	741	1,126
9[a]	2,393	2,434	2,499	1,479	1,017	503	780	904	52	31	306	259	719	1,077
10	2,334	2,393	2,442	1,432	961	476	717	851	86	74	381	272	688	1,015
11	2,289	2,352	2,417	1,451	927	424	726	906	148	105	359	204	640	1,015
12	2,357	2,405	2,422	1,339	977	531	647	722	114	179	502	388	732	956
13	2,132	2,175	2,187	1,166	761	371	440	718	278	348	645	393	539	737
14[a]	1,977	2,037	2,103	1,256	610	176	560	935	308	416	547	239	381	808
15	1,872	1,913	1,932	1,046	505	278	321	842	511	576	828	502	341	545
16	1,737	1,788	1,848	1,116	364	217	437	1,003	606	666	869	520	183	578
17	1,857	1,920	2,006	1,257	496	57	542	1,026	478	533	702	353	213	733
18	2,329	2,385	2,426	1,400	952	477	689	817	84	108	418	296	687	990

(Continued on next page.)

APPENDIX TABLE 4--continued.

Destination	Origin 1	2[a]	3[a]	4	5[a]	6	7	8	9[a]	10[a]	11[a]	12	13	14
	miles													
19	2,367	2,400	2,289	1,230	995	598	573	584	245	317	638	512	779	889
20	2,326	2,342	2,290	1,060	980	669	457	425	425	496	815	658	815	768
21	2,256	2,259	2,170	892	946	731	354	344	590	653	973	784	839	643
22	2,529	2,511	2,360	914	1,273	1,070	647	0	817	897	1,207	1,083	1,182	871
23	1,943	1,969	1,969	985	585	370	248	735	551	570	849	546	448	519
24	1,975	1,986	1,938	848	659	524	120	620	634	669	965	687	580	433
25	2,082	2,079	1,980	743	813	701	184	463	708	758	1,077	831	761	454
26	1,986	1,962	1,820	532	816	840	241	551	922	971	1,277	1,015	850	324
27	1,785	1,767	1,659	566	632	747	204	745	960	989	1,279	978	711	130
28	2,030	1,989	1,808	418	930	980	381	555	1,041	1,088	1,409	1,152	985	389
29	1,524	1,491	1,358	529	588	908	490	1,026	1,226	1,239	1,516	1,187	801	175
30	1,729	1,667	1,455	259	850	1,091	555	916	1,305	1,334	1,635	1,335	1,021	307
31	1,184	1,091	852	742	875	1,341	1,006	1,506	1,731	1,729	1,993	1,647	1,182	691
32[a]	1,632	1,646	1,613	801	373	535	301	947	844	906	1,135	821	444	272
33	1,467	1,496	1,539	974	148	510	487	1,132	980	971	1,164	825	348	430
34	1,622	1,676	1,759	1,145	256	276	515	1,112	794	770	945	595	121	595
35	1,395	1,457	1,584	1,207	108	475	687	1,317	1,019	992	1,133	788	260	665
36	1,108	1,184	1,368	1,320	305	759	932	1,576	1,312	1,279	1,399	1,061	543	825
37	1,267	1,309	1,393	1,086	114	642	690	1,337	1,156	1,137	1,313	961	439	576

(Continued on next page.)

APPENDIX TABLE 4--continued.

Destination	Origin													
	1	2a/	3a/	4	5a/	6	7	8	9a/	10a/	11a/	12	13	14
	miles													
38	1,369	1,393	1,417	932	188	632	548	1,194	1,099	1,088	1,297	948	460	413
39	1,437	1,420	1,342	682	438	807	494	1,093	1,182	1,183	1,443	1,103	676	227
40	1,021	988	932	932	604	1,117	929	1,523	1,575	1,559	1,780	1,434	930	653
41	845	848	915	1,152	595	1,129	1,060	1,684	1,636	1,608	1,799	1,448	922	819
42	607	682	943	1,480	761	1,262	1,324	1,965	1,804	1,778	1,905	1,567	1,046	1,119
43	405	353	552	1,512	1,075	1,610	1,553	2,160	2,131	2,101	2,273	1,925	1,397	1,289
44	701	632	597	1,215	906	1,442	1,301	1,887	1,932	1,907	2,111	1,761	1,239	1,019
45	1,114	973	597	956	1,174	1,664	1,332	1,797	2,061	2,052	2,320	1,973	1,495	1,016
46	861	675	188	1,374	1,408	1,942	1,696	2,201	2,391	2,397	2,610	2,260	1,750	1,385
47	572	390	210	1,517	1,325	1,866	1,714	2,275	2,360	2,329	2,538	2,185	1,661	1,419
48	187	22	570	1,841	1,402	1,926	1,902	2,511	2,461	2,428	2,577	2,235	1,710	1,640
49	0	209	742	1,916	1,365	1,867	1,903	2,529	2,423	2,382	2,502	2,167	1,650	1,662

a/ Distance estimated as described on pages 10 and 11 of text.

Source: U. S. Department of Commerce, Coast and Geodetic Survey, Airline Distances Between Cities in the United States, Special Publication No. 238, 1947, 246p.

APPENDIX TABLE 5

Highway Distance Between 14 Points of Origin and 49 Destination Points

Destination	Origin													
	1	2[a]	3[a]	4	5[a]	6	7	8	9	10[a]	11[a]	12	13	14
	miles													
1	3,144	3,263	3,337	2,224	1,505	964	1,392	1,513	546	450	95	463	1,258	1,669
2	3,057	3,176	3,250	2,158	1,418	877	1,299	1,447	480	384	63	376	1,171	1,582
3	3,030	3,149	3,223	2,142	1,391	851	1,272	1,483	513	417	218	342	1,144	1,555
4	3,080	3,199	3,273	2,119	1,441	900	1,287	1,408	441	345	32	400	1,194	1,605
5	3,076	3,195	3,266	2,077	1,437	896	1,255	1,366	399	303	75	396	1,190	1,564
6	2,996	3,098	3,164	1,975	1,357	817	1,143	1,264	297	201	176	360	1,110	1,462
7	2,905	3,024	3,098	2,006	1,266	725	1,147	1,332	362	266	207	225	1,019	1,430
8	2,873	2,975	3,041	1,841	1,234	694	1,009	1,130	163	67	310	316	987	1,339
9	2,870	2,973	3,036	1,811	1,232	692	979	1,100	57	87	416	384	985	1,334
10	2,771	2,873	2,947	1,710	1,132	592	878	999	158	112	441	338	885	1,233
11	2,749	2,848	2,917	1,729	1,110	570	897	1,072	188	126	423	262	863	1,215
12	2,860	2,951	2,950	1,609	1,221	688	777	851	306	260	589	486	974	1,151
13	2,566	2,633	2,664	1,422	927	444	552	913	557	510	824	505	680	917
14	2,373	2,492	2,566	1,486	734	194	631	1,145	565	504	739	320	487	901
15	2,273	2,319	2,361	1,244	631	316	395	1,018	732	673	978	559	387	659
16	2,089	2,214	2,288	1,322	450	277	489	1,184	839	777	1,023	604	203	711
17	2,295	2,412	2,486	1,489	656	71	640	1,222	719	657	903	484	409	893
18	2,780	2,882	2,934	1,672	1,141	601	840	961	196	150	479	376	894	1,214
19	2,917	2,984	2,876	1,485	1,278	795	703	694	317	418	747	644	1,031	1,077
20	2,895	2,923	2,724	1,293	1,253	859	584	492	518	629	958	829	1,009	925

(Continued on next page.)

APPENDIX TABLE 5--continued.

Destination	Origin													
	1	2[a]	3[a]	4	5[a]	6	7	8	9	10[a]	11[a]	12	13	14
	miles													
21	2,863	2,814	2,601	1,091	1,172	908	443	387	753	827	1,156	1,021	1,009	774
22	3,235	3,170	2,856	1,238	1,550	1,286	796	0	992	1,111	1,440	1,325	1,387	1,107
23	2,386	2,405	2,388	1,188	744	416	318	914	773	714	1,020	617	500	683
24	2,514	2,465	2,355	1,020	861	606	141	727	895	849	1,178	802	660	515
25	2,678	2,613	2,370	903	1,014	824	239	557	965	919	1,248	1,002	878	550
26	2,591	2,492	2,160	657	1,013	982	277	696	1,218	1,172	1,501	1,205	963	432
27	2,360	2,291	2,001	662	767	898	224	952	1,255	1,209	1,538	1,141	848	161
28	2,598	2,499	2,167	506	1,131	1,155	450	736	1,366	1,320	1,649	1,379	1,126	502
29	2,034	1,935	1,645	604	719	1,098	574	1,289	1,525	1,466	1,771	1,352	997	195
30	2,230	2,117	1,780	300	988	1,320	649	1,144	1,672	1,634	1,963	1,570	1,234	369
31	1,543	1,430	1,091	879	1,100	1,580	1,128	1,765	2,043	1,984	2,289	1,870	1,449	749
32	2,100	2,035	1,993	976	450	644	355	1,151	1,103	1,044	1,349	930	567	320
33	1,849	1,872	1,946	1,113	186	611	603	1,397	1,166	1,103	1,359	940	421	503
34	1,946	2,071	2,230	1,390	307	420	573	1,323	982	920	1,166	747	135	764
35	1,660	1,823	2,094	1,371	131	706	828	1,582	1,268	1,206	1,452	1,033	288	761
36	1,363	1,526	1,832	1,530	381	1,041	1,163	1,918	1,603	1,541	1,787	1,368	623	1,005
37	1,573	1,736	1,872	1,242	122	830	884	1,671	1,392	1,330	1,576	1,157	514	683
38	1,745	1,733	1,807	1,080	249	751	710	1,490	1,301	1,239	1,499	1,080	561	502
39	1,911	1,823	1,649	771	535	981	660	1,388	1,444	1,385	1,690	1,271	850	325
40	1,413	1,314	1,353	1,087	741	1,296	1,124	1,896	1,801	1,742	2,055	1,623	1,104	817

(Continued on next page.)

APPENDIX TABLE 5--continued.

Destination	Origin													
	1	2[a]	3[a]	4	5[a]	6	7	8	9	10[a]	11[a]	12	13	14
	miles													
41	1,160	1,153	1,257	1,379	730	1,348	1,302	2,082	1,910	1,848	2,094	1,675	1,121	1,076
42	821	984	1,316	1,808	930	1,599	1,698	2,476	2,161	2,099	2,345	1,926	1,181	1,493
43	550	451	737	1,870	1,479	2,032	1,939	2,719	2,579	2,517	2,780	2,361	1,788	1,679
44	926	827	835	1,494	1,152	1,722	1,629	2,361	2,269	2,207	2,470	2,051	1,530	1,303
45	1,577	1,310	745	1,132	1,543	2,023	1,571	2,171	2,486	2,427	2,732	2,313	1,892	1,192
46	1,075	808	243	1,634	1,876	2,428	1,976	2,613	2,891	2,832	3,137	2,718	2,254	1,597
47	778	511	313	1,906	1,681	2,251	2,158	2,799	2,813	2,736	2,999	2,580	2,059	1,783
48	241	26	711	2,333	1,821	2,495	2,402	3,182	3,042	2,980	3,243	2,824	2,085	2,142
49	0	267	952	2,420	1,684	2,366	2,452	3,235	2,928	2,866	3,112	2,693	1,948	2,229

[a] Distance estimated as described on pages 10 and 11 of text.

Source: Household Goods Carriers' Bureau, Mileage Guide No. 4 (Washington, D. C., December), 1941, 384p.

APPENDIX TABLE 6

Transfer Charge Relationships Derived from Motor Carrier Data for Frozen Vegetables Using Highway Mileage as a Measure of Distance

Equation form[a]	Number of observations	R^2	Constant term	Regression coefficients		t-ratios	
				Distance	Weight	Distance	Weight
1. $C_T = f(X_2, X_3)$	486	0.761	228.812	0.117	-5.627	34.700	-16.772
2. $C_T = f(X_2, X_3)$ W-E	193	0.743	327.744	0.086	-7.330	14.847	-15.934
3. $C_T = f(X_2, X_3)$ E-W	107	0.613	187.021	0.112	-3.776	12.763	- 3.338
4. $C_T = f(X_2, X_3)$ Other	186	0.813	123.888	0.155	-3.014	26.952	- 6.602
5. $C_T = f(X_2) < 27M$	192	0.907	51.100	0.176		43.020	
6. $C_T = f(\log X_2) < 27M$	192	0.755	-684.894	316.146		24.203	
7. $C_T = f(X_2)$ 27-33M	248	0.655	84.254	0.084		21.612	
8. $C_T = f(\log X_2)$ 27-33M	248	0.726	-315.193	167.921		25.561	
9. $C_T = f(X_2) > 33M$	46	0.658	60.113	0.126		9.211	
10. $C_T = f(\log X_2) > 33M$	46	0.720	-409.241	202.456		10.659	

[a] C_T = charges per hundredweight.
X_2 = highway distance, miles.
X_3 = minimum load weight, thousand pounds.
log = logarithm to the base 10.
M = thousand pounds.
W-E = west to east; E-W = east to west; and Other = all directions other than E-W and W-E.

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